International Yield Co-movements*

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Abstract

We decompose 5 year nominal bond yields into real and inflation components in an international context using inflation-linked and nominal bonds since 2004. Real rate variation dominates the variation in inflation-linked and nominal yields, but liquidity and inflation risk premiums are also important. Cross-country nominal and inflation-linked yield correlations have declined since the Great Recession. Real rates are the main source of the correlation between nominal yields. A slow-moving risk aversion variable from a habit model explains a substantive part of the variation in real yields and cross-country yield correlations, thereby outperforming a measure of the monetary policy stance.

Keywords: sovereign bonds, cross-country co-movement, real yield, expected inflation, inflation risk premium, liquidity premium, habit formation, inflation-linked bonds

JEL codes: E31, E43, G12, G15

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1 Introduction

The nominal yield on a government bond can be decomposed into a real yield, expected inflation and an inflation risk premium. The decomposition is of critical economic interest because policymakers react very differently to expected inflation changes than to shifts in real yields or the inflation risk premium. However, if the market only trades nominal bonds, all three components are unobserved. To identify these components, an extensive literature has used a variety of techniques. The approach typically involves estimating a term structure model, which implicitly involves restrictions on the dynamics of state variables and risk compensation to achieve identification (see, e.g., Ang, Bekaert, and Wei, 2008). Recent models have tried to alleviate the identification problem by using survey data to (help) identify expected inflation, and inflation-linked bonds to help tie down real rates (see e.g. D'Amico, Kim, and Wei, 2018). The older literature, which does not use inflation-linked debt, typically finds that inflation compensation (expected inflation and the inflation risk premium) accounts for most of the variation of nominal yields and nominal term spreads (see Bekaert and Wang, 2010, for a survey). For example, Ang, Bekaert, and Wei (2008) find that variation in expected inflation and inflation risk premium explains about 80% of the variation in nominal rates.

Against a backdrop of media reports suggesting "inflation is dead" (Coy, 2019; Economist, 2019), we re-examine this important decomposition with more recent data, ensuring that we can rely on inflation-linked debt yields. Yet, the use of inflation-linked bonds also creates various challenges. First, the time series sample is relatively short, starting only in 2004. Our main focus therefore will be on co-movements and variances, rather than level averages, which may be too sensitive to the time period at hand. Second, the secondary market for inflation-linked debt tends to be less liquid than that for nominal bonds. The relative liquidity premium has varied over time and prevents the use of inflation-linked yields as direct proxies for real rates. Estimates by Gürkaynak, Sack, and Wright (2007) and D'Amico, Kim, and Wei (2018) show the liquidity premiums in the US to be well over 1% annually in the first 3 to 5 years after inception.[1] The liquidity premiums became much smaller around 2004 but were far from negligible even then. We estimate liquidity premia using state-of-the art methods. Rather than just focusing on the US alone, we examine the standard yield decomposition using both nominal and inflation-linked debt from an international perspective and study the co-movements of yields and their components across countries. We focus on France and the UK, because they have long time series on inflation-linked yields.

Our main findings are as follows. First, over the last 15 years, nominal and inflation-linked yields have decreased over time, and their standard deviations have (mostly) decreased. Internationally, these observed yields correlate highly but their correlation has decreased over time. Second, expected inflation plays no role in these developments. Instead, real yields are the dominant component contributing to the variation in inflation-linked and nominal yields.[2] Liquidity premiums have only decreased in the US, but inflation risk premiums have decreased everywhere, and this decrease is statistically significant. Real yields are also the dominant component in explaining co-movements across countries.

To economically interpret our results, we set out a consumption-based asset pricing model with habit preferences that links real yields to expected consumption growth, consumption growth uncertainty and stochastic risk aversion. While the recent period has been dominated by "unusual" monetary policy experiments, it is still important to ascertain whether economic fundamentals can explain some of the yield variation in the data. Because of the various crises over the last decade, real economic uncertainty

[1] Similar results are also documented, for instance, by Sack and Elsasser (2004), Shen (2006), Abrahams et al. (2016), and Pflueger and Viceira (2016).

[2] This result is reminiscent but different from the result in Duffee (2018) who avoids the use of inflation-linked yields. He finds that expected inflation *news* contributes little to the variation in *shocks* to nominal bond yields. His computations (see Table III) do suggest that these inflation variance ratios also decreased in 2008-2013 relative to earlier periods.

may have played an important role in yield dynamics. If inflation uncertainty and real uncertainty are correlated, increases in uncertainty may also affect the inflation risk premium. Our model predicts that risk aversion variation affects yields, but the direction of the effect depends on whether intertemporal smoothing or precautionary savings effects dominate. Coupled with an inflation model, we link nominal yields, real yields and inflation risk premiums to the economic determinants implied by the model and to a measure of the monetary policy stance, and ask how much interest rate variation and co-movements these economic variables explain. We find that a proxy for slow-moving risk aversion driven by consumption shock realizations, as in the habit model, is the most important determinant of real yields, helping to explain the stylized facts for variance and co-movement decompositions.

Our contribution is twofold. First, while the literature on international asset return co-movements is vast (see Bekaert et al., 2016, for a recent survey), surprisingly little research exists on yield correlations across countries. Jotikasthira, Le, and Lundblad (2015) examine correlations across nominal yields in the US, UK, and Germany through the lens of a reduced-form term structure model with inflation and real activity as main factors. They mostly distinguish a "policy" channel (the short rate and its effect of long term yields through the expectations hypothesis) and "risk compensation" channel (term premiums). They find that nominal yields are highly correlated across countries, with both channels explaining roughly equal parts of the total variation for 5 year yields. In a contemporaneous paper, Berardi and Plazzi (2019) estimate a reduced-form term structure model to compute yield correlations across 4 major economies, focusing, similarly to Jotikasthira, Le, and Lundblad (2015), on short rate expectations and term premiums. We extend these papers by decomposing the cross-country yield correlations into real yield, expected inflation and the inflation risk premium components (real yield and the liquidity premium components for inflation-linked bonds). It is this decomposition that allows us to examine the economic determinants of international yield co-movements through the lens of a consumption-based asset pricing model.[3]

Our second contribution is to establish and economically interpret a set of stylized facts regarding yield decompositions. The extant literature performing such decompositions using inflation-linked yields has either ignored the liquidity premium[4] or focuses on an individual time series, such as real yields in Campbell, Shiller, and Viceira (2009), arbitrage profits in Fleckenstein (2013) and Fleckenstein, Longstaff, and Lustig (2014), the inflation risk premium in Grishchenko and Huang (2013), expectation hypothesis violations in Pflueger and Viceira (2016), expected inflation in Kaminska et al. (2017), the liquidity premium in D'Amico, Kim, and Wei (2018), or the issuance costs of inflation-linked versus nominal bonds in Ermolov (2018). We provide a comprehensive analysis on the relative importance of different yield components in multiple countries linking them to macroeconomic drivers motivated by our macro-finance equilibrium model of interest rates.

The remainder of the paper proceeds as follows. Section 2 provides the analytics behind our decompositions. Section 3 describes the basic data and their sources and provides initial statistics on measured yields. Section 4 provides the main variance and co-movement decompositions, after identifying the liquidity premium in inflation-linked debt yields. Section 5 describes the consumption-based asset pricing model and how well economic factors predicted by the model can replicate the real yield patterns

[3]Bayoumi and Swiston (2010) investigate high frequency spillovers between inflation-indexed yields in the United States and other countries finding inflation-linked yields to be closely linked across countries, with developments in U.S. markets affecting real foreign yields and no evidence of spillovers back to the United States. Our focus is instead on contemporaneous low frequency macro-driven fluctuations.

[4]Among others, Christensen, Lopez, and Rudebusch (2008) and Chen, Engstrom, and Grishchenko (2016) for the US, Evans (1998 and 2003), Risa (2001), Joyce, Lildhodlt and Sorensen (2008), for the UK, Garcia and Werner (2010), Hördahl and Tristani (2014), and Pericoli (2014), for the euro area. Haubrich, Pennacchi, and Richken (2012) use inflation swap rates instead of TIPS to estimate the various components assuming perfect liquidity in inflation swap markets, an assumption Christensen and Gillan (2012) and To and Tran (2019) criticize.

in the data. Section 6 investigates the ability of economic factors to explain inflation risk premiums and nominal yields. In Section 7, we conduct two additional exercises. First, we investigate similar decompositions for yield spreads rather than yield levels. Second, we re-derive our main results for a wider sample of countries, but a shorter time period. The final section concludes.

2 Decomposing Yields: on Liquidity and Inflation Risk Premiums

Throughout this article, we work with continuously compounded yields on zero-coupon government bonds. The main decomposition of interest is:

$$\underbrace{y_t^n}_{\text{nominal rate}} = \underbrace{r_t^n}_{\text{real rate}} + \underbrace{E_t[\pi_{t,t+n}^n]}_{\text{expected inflation}} + \underbrace{\varphi_t^n}_{\text{inflation risk premium}}, \tag{1}$$

where y_t^n is the yield on a nominal zero-coupon bond of maturity n, r_t^n is the yield on a perfectly indexed zero coupon bond of maturity n, and $\pi_{t,t+n}^n$ is (average) inflation from t to $t+n$. The difference between y_t^n and r_t^n is often called "inflation compensation" or sometimes "breakeven inflation rate". Inflation compensation economically consists out of two components. The first is simply expected inflation; the second is the inflation risk premium, the compensation investors demand to protect themselves against inflation risk.

The Fisher hypothesis holds that the inflation risk premium is zero, but is inconsistent with both modern asset pricing theory and recent empirical estimates of the inflation risk premium. In typical asset pricing models, the inflation risk premium depends on the covariance between the real pricing kernel and inflation. That is, the inflation risk premium is positive if inflation is high in "bad times", as the pricing kernel takes on high values in bad states of the world. Of course, this covariance between the wealth or consumption of agents and inflation may well vary through time and entail substantial variation in the conditional inflation risk premium. Campbell, Sunderam, and Viceira (2017) stress how positive correlation between inflation and stock returns (as an indicator of "wealth") may imply negative inflation premiums, and Bekaert, Engstrom, and Ermolov (2018) discuss how aggregate demand environments, where real activity is negatively correlated with inflation, may coincide with negative inflation risk premiums.

Liquidity premiums in inflation-linked debt considerably complicate the identification problem embedded in equation (1), because inflation-linked yields do not deliver r_t^n. Let's denote zero-coupon yields derived from inflation linked debt, as $r_t^{n,IL}$, then they consist of two components:

$$r_t^{n,IL} = r_t^n + LiqPr_t^n, \tag{2}$$

where $LiqPr$ represents a liquidity premium that may vary through time.

Despite the obvious identification problems, we can make an important step forward by taking a stand on inflation expectations. The recent literature has increasingly relied on survey forecasts, by either professionals or consumers, which are now available for multiple countries. In fact, Ang, Bekaert, and Wei (2007) find that survey forecasts (in particularly, the Survey of Professional Forecasters, SPF) consistently beat other models in forecasting U.S. inflation out-of-sample.

Assuming inflation expectations are observed, data on inflation-linked and nominal yields do generate direct information on an important concept, which we dub the nominal debt premium. That is, $NDPR_t^n = y_t^n - r_t^{n,IL} - E_t[\pi_{t+n,n}^n]$. From (1) and (2), it follows that $NDPR_t^n = \varphi_t^n - LiqPr_t^n$. The nominal debt premium is the difference between the inflation risk premium, priced in nominal bonds, and the liquidity premium, priced in inflation-linked debt. It represents the real cost advantage or disadvantage of the government issuing nominal versus real debt.

3 Data and Initial Stylized Facts

Our yield data comprise end-of-month zero-coupon yields extracted from nominal and inflation-linked bonds from France, the UK, and the US. The sample starts in 2004 because before this date an insufficient number of bonds are available to create yield curves, especially in France. For France, we use the bonds linked to euro area inflation, rather than to local inflation. Zero-coupon yields for the US, both for nominal Treasuries and Treasury inflation-protected securities (TIPS), are from Gürkaynak, Sack, and Wright (2007 and 2010, respectively). The UK zero-coupon nominal and inflation-linked yields are from the Bank of England web site. For France, the nominal yields are from the Banque de France website. We use the Nelson-Siegel (1987) methodology to construct French zero-coupon yields from inflation-linked bond prices taken from Bloomberg. Note that all computations are based on off-the-run bonds. For inflation-linked debt, no bonds with residual maturity below 12 months are used, because their prices are strongly affected by indexation lags and seasonality effects. Because inflation-linked debt tends to be issued at relatively long maturities, the main security we focus on is the 5 year zero-coupon bond. As our analysis is based mainly on off-the-run long maturity bonds, we assume that the deflation protection and indexation lag premia embedded in inflation-linked bond prices are zero (see Risa, 2001, and D'Amico, Kim, and Wei, 2018). For more details on data construction, see Ermolov (2018). We provide some institutional backgrounds regarding the three markets primarily analyzed in this article in Appendix I.

In Table 1, we show the properties of the 5 year yields, with nominal yields on the left and inflation-linked yields on the right and three panels for the full sample, the first half of the sample (2004 till 2010) and second half of the sample (2010-2016). We show standard errors from a GMM procedure, outlined in Appendix II, incorporating 12 Newey-West (1987) lags. Asterisks in the second subsample indicate values statistically different from the first subsample. It should not be any surprise that yields have significantly decreased with inflation-linked yields becoming negative in the second sub-sample. The standard deviations of yields have decreased as well, except for nominal yields in France.[5] However, these changes are not statistically significantly different from zero.

For the full sample, we confirm the result in Jotikasthira, Le, and Lundblad (2015) that nominal yields are highly correlated across countries, with the correlation varying between 0.79 for the US and France and 0.95 for the US and the UK. The inflation-linked yield correlations are of the same order of magnitude. When looking at the subsamples however, we see that these correlations have decreased substantially. The correlation decrease is particularly striking (and statistically significant) for the correlation of French yields with US yields, which has become essentially zero. This is not due to a volatility effect, which we can infer from the statistics for US betas. These betas represent the exposure of French and UK yields to US yields (as implied by a linear regression with a constant). The US beta for French nominal (inflation-linked) yields has also decreased from 0.46 (0.53) to 0.15 (-0.01). For the UK, its nominal yield beta significantly increases while its inflation-linked yield beta decreases substantially from the first to the second subsample.

Inflation-linked bonds may result in debt cost savings for the government, when the inflation risk premium is larger than the liquidity premium priced in inflation index-linked bonds. We now provide direct estimates of the relative interest rate cost of issuing nominal versus inflation-linked debt, by first measuring inflation expectations. We take 5 year expected inflation from Aruoba (2016) for the US, who aggregates data from multiple surveys, from the European Central Bank Survey of Professional Forecasters for France and from Consensus Economics for the UK. Figure 1 graphs these expectations, clearly showing inflation expectations to be higher in the UK, followed by the US and then France, where inflation expectations are very sticky,

[5] This is potentially linked to the decrease in levels if interest rates show Cox, Ingersoll, Ross (1985) type heteroskedasticity.

barely changing over time.

In Table 2, we report the statistical results on expected 5 year inflation, as measured by the surveys (left-hand side). Average inflation expectations range from 1.92% in France to 2.90% in the UK. Therefore, the expectations are very near the inflation targets set by the European and US central banks (which are at 2%) but quite a bit above the target set by the Bank of England. While inflation is far from dead, as is sometimes claimed in recent media reports, its stochastic process has definitely changed. D'Amico, Kim and Wei (2018) report standard deviations for expected inflation over various horizons invariably exceeding 1%. Inflation expectations are now very stable, as witnessed by the low standard deviations, especially in France and the US, where the standard deviation is less than 10 basis points. For those two countries, the average expected inflation is stable over the two sample periods. In the UK, inflation expectations have actually increased to well over 3% in the second half of the sample from 2.6% in the earlier sample, and the change is statistically significant. The standard deviation is around 20 to 25 basis points in both samples. The low volatility of the inflation expectations may partially reflect the long horizons over which expectations are formed but may also derive from monetary policy's ability to anchor inflation expectations. In Appendix III, we repeat the information in Table 2 but for one year ahead inflation expectations. These expectations are more variable, exhibiting standard deviations in the 35 to 40 basis points range.

Perhaps surprisingly, inflation expectations are not highly correlated cross countries. Yet, Monacelli and Sala (2009) find that for inflation rates in the US, UK, France, and Germany an international common factor explains less than 30% of the inflation variance. The correlation between expected inflation in the UK and the US is negative, which is also reflected in a very large but negative beta with respect to US inflation. Expected inflation in the UK and France are positively correlated at 0.4. The table does reveal that these results are all due to the first part of the sample. More recently, expected inflation in France and the UK show a 0.82 correlation whereas US expected inflation correlate around 0.29 with expected inflation in the UK and France.

The right panel of Table 2 shows properties of the nominal debt premium. The nominal debt premium has been on average negative in all three countries, ranging from -31 basis points in France to -46 basis points in the US. In the two European countries nominal debt premiums decreased substantially in a statistically significant manner in the second subsample. It appears that governments have enjoyed a substantive yield advantage issuing nominal debt. While it is tempting to associate this finding with the unusual monetary policies in Europe and elsewhere, note that monetary policy should primarily affect real yields. However, low inflation risk premiums relative to liquidity premiums, may also arise from the ability of nominal bonds to hedge real risk in aggregate demand environments, and correlate negatively with equity returns in periods of market stress. From that perspective, it is surprising that the nominal debt premiums are lower in the second part of the sample, as the first half of the sample was dominated by the Great Recession, in which bond and stock returns were mostly negatively correlated and which is mostly characterized as an aggregate demand recession (see Mian and Sufi, 2010). Nominal debt premiums have become less correlated across countries, with the decrease significant for the pairs involving the UK.

4 Empirical Decomposition Results

To actually implement the decompositions in equation (1), we must identify the liquidity premium or the inflation risk premium. Here, we first estimate the liquidity premium and then show properties of the resulting liquidity and inflation risk premiums. With all the components in hand, we provide variance decompositions of the three yield components in the three countries and a decomposition of the correlation dynamics across countries of nominal and inflation-linked yields.

4.1 The Liquidity Premium

To estimate the liquidity premium, we follow the methodology in Gürkaynak et al. (2010). We run the following regression:

$$NDPR^{n}_{t,i} = c_{1,i} + c'_2 l_{t,i} + \epsilon_{t,i}, \tag{3}$$

where $NDPR^{n}_{t,i}$ is the nominal debt premium in country i, $l_{t,i}$ is a vector of country-specific liquidity proxies and $\epsilon_{t,i}$ is the error term. Recall that the debt premium equals the inflation risk premium minus the liquidity premium. Therefore, if the liquidity proxies indicate illiquidity we expect the coefficients to be negative. In addition, for the procedure to correctly identify the liquidity premium, the liquidity proxies should be uncorrelated with the inflation risk premium. Given the slope coefficients from equation (3), $\hat{c}_2$, the liquidity premium in country i at time t can be computed as $-\hat{c}_2 l_{t,i}$. Obviously, the mean of the liquidity premium is not identified through this procedure.

We use three types of liquidity proxies: the nominal off-the-run spread, the relative outstanding amount of inflation-linked bonds, and the inflation swap spread. The nominal off-the-run spread is the difference between yields of the most recent and older nominal bonds of the same maturity offering almost identical cash flows (see Krishnamurthy, 2002, for the US and Geyer et al., 2004, internationally). Following Hu, Pan, and Wang (2013), we construct the off-the-run spread by estimating a nominal yield for a particular maturity using the cross-section of all bonds (most of which are off-the-run) and subtracting the on-the-run yield from Bloomberg. Hu, Pan, and Wang (2013), among others, propose the spread as an indicator of the overall demand for liquidity (higher spreads indicating stronger demand and higher liquidity premiums). Although the off-the-run spread is not directly linked to the inflation-linked bond liquidity, a voluminous literature, starting with Chordia, Sarkar, and Subrahmanyam (2005), suggests that there is strong commonality in liquidity between different markets.

The relative outstanding amount of inflation-linked bonds is the nominal value of outstanding inflation-linked bonds divided by the nominal value of outstanding inflation-linked and nominal bonds. This variable reflects the general market development of the inflation-linked market, as more debt outstanding likely implies a more comprehensive term structure of inflation-linked debt, more regular issue calendars etc. The outstanding amount may also be correlated with trading volumes, a variable we were unable to track down for the French market. We obtain the data on nominal outstanding amounts of nominal and inflation-linked debt from the Agence France Trésor, for France, from the United Kingdom Debt Management Office for the UK, and from the Bank of International Settlements for the US.

The inflation-swap spread is defined as the price of a zero-coupon inflation swap position paying fixed and receiving floating minus the difference between the zero-coupon nominal and inflation-linked yields. The inflation swap quote is the risk neutral expectation of future inflation and thus essentially represents inflation compensation (including expected inflation and the inflation risk premium). The nominal yield which is subtracted, also incorporates inflation compensation. In the absence of market frictions and liquidity differences, this spread should therefore be 0, as the inflation-linked yield would simply correct for the real yield. The inflation swap spread should therefore reflect the liquidity premium embedded in inflation-linked yields. Fleckenstein (2013) and Fleckenstein, Longstaff, and Lustig (2014) show that the spread varies substantially over time. Because the spread is in principle arbitragable, they also link it to the strength of arbitrage activity in debt markets.[6] Following Pflueger and Viceira (2016), we use the end of month inflation swap spread, with the inflation swap rate taken from Bloomberg.

Finally, we include a coarse measure of market development, the log of the number of months since inception. It is typically the case that early inflation-linked programs

[6] To and Tran (2019) claim that inflation swaps may exhibit overpricing as well, which would bias our liquidity premium estimates upwards.

are associated with poor liquidity, uncertainty about the viability of the market, incomplete availability of bonds along the maturity spectrum and irregular issuance calendars (e.g., Campbell, Shiller, and Viceira, 2009). From that perspective the UK has a much longer experience with inflation-linked debt than the other countries. However, because the variable only depends on time, it may also reflect trending behavior in the inflation risk premium. For example, Bekaert and Wang (2010) survey a large number of empirical studies on the inflation risk premium and show that studies with shorter, more recent samples tend to find smaller average inflation risk premiums.

We run a panel regression with monthly data including all three countries, imposing c_2 to be the same across countries. The results are very similar using quarterly observations. Table 3 first shows univariate results for each independent variable, with and without country fixed effects, before showing the full specification with all 4 independent variables and country fixed effects.

In line with economic intuition, the off-the-run spread and inflation swap spreads have statistically significant negative coefficients, while the log share of total government debt accounted for by inflation-linked debt has a significantly positive coefficient. Months since inception has a negative coefficient which is only significant when country fixed effects are introduced. Thus, the variable suggests an upward trend in the liquidity premium that is stronger for the countries with more recent inflation-linked debt programs, but it may also reflect downward trends in the inflation risk premiums. In specification 9, we use all 4 variables and country fixed effects. First, note that the adjusted R^2 is 67.5% suggesting the fit is very good. The off-the-run spread is the only variable that is not significant. We therefore use specification 10 in our estimates of the liquidity premium, which only features the inflation swap spread, the log(share of inflation-linked debt) and log (months since exception) and actually has a higher adjusted R^2 than Specification 9. Panel A of Figure 2 graphs the three estimated liquidity premiums over time.

We conduct two robustness checks. First, we re-estimate the models country by country rather than in a panel. All our results remain robust. We provide the country-by-country results in Appendix IV. Second, we consider a model where we only use the inflation swap spread as an independent variable. For other variables, there is some chance that their temporal evolution may correlate with the magnitude of inflation risk premiums, which would bias our estimates. For example, the inflation-linked debt issuance volumes may depend on the magnitude of the inflation risk premium. Again, our results, reported in Appendix IV, are robust, which is not surprising given that the inflation swap spread has by far the highest explanatory power for variation in the nominal debt premium.

4.2 Liquidity and Inflation Risk Premiums

Given the presence of fixed effects and the use of the nominal debt premium on the left hand side, it is impossible to tie down the level of the liquidity premium. This is immaterial for most of our results, which focus on volatility, variance decompositions, and comovements. However, to graph the liquidity and inflation risk premiums, and report averages, we follow Gürkaynak, Sack, and Wright (2010), normalizing the level of the liquidity premium to zero at the point in time at which it was the lowest. Once the liquidity premium is identified, we identify real rates from inflation-linked yields using equation (2), and the inflation risk premium is simply:

$$\varphi_t^n = y_t^n - E_t[\pi_{t+n,n}^n] - r_t^n. \tag{4}$$

In Table 4, we produce characteristics of liquidity (left panel) and inflation risk premiums (right panel). Using our procedure (which, assuming liquidity premiums are always positive, might somewhat under-estimate the magnitude of liquidity premiums), we still find them to be at least 50 basis points on average in all three samples. In the US, the liquidity premium decreases significantly from 78 to 42 basis points, which is not surprising given that liquidity premiums were high during the Great Recession. However, in both the UK and France, liquidity premiums increased, now being higher than 1% in the UK. This may be related to the continuing poor economic conditions in Europe. Liquidity premiums vary substantially through time, especially in the US and the UK where the standard deviation is 50 and 40 basis points, respectively. In France, it is only 29 basis points. In the UK and the US, the standard deviation of the liquidity premiums has decreased to French levels (UK) or even lower (the US) in the second part of the sample. Liquidity premiums comove positively across countries, with correlations in the 0.35 to 0.50 range. Such correlation is not surprising: Panyanukul (2010) shows strong commonality of liquidity risk in international government bond markets, finding the US market to be an important source of global liquidity risk. These correlations have decreased over time, particularly between France and the other countries, where they are very small more recently. This decrease is statistically significant.

Inflation risk premiums are on average quite small in France and the US (15-20 basis points), but larger in the UK (60 basis points). They have decreased substantially over time, in a statistically significant manner, in all three countries and are now negative in the US and France. This confirms the claim in Chen, Engstrom, and Grischenko (2016) that the recent decrease in inflation compensation in the US can be attributed to lower inflation risk premiums. Their volatility is about 40-45 basis points, which has decreased over time to 30-35 basis points. Note that the standard deviation of the inflation risk premiums is smaller in both subsamples than it is over the full sample, which is related to the very steep decrease in the inflation risk premium average. Inflation risk premiums are highly positively correlated across countries (e.g. the correlation between US and French inflation risk premiums is invariably above 70%). However, UK inflation risk premiums of late have decoupled from the ones in the US and France, with correlations dropping to -0.06 for the UK and France, and 0.03 for the UK and the US.

We graph the inflation risk premiums in Panel B of Figure 2. At the height of the

Great Recession (roughly at the end of 2008 to the first quarter of 2009), there is a downward spike in the inflation risk premium, which coincides with an upward spike in the liquidity premium (see Panel A of Figure 2). While highly positive liquidity and low inflation risk premiums are not surprising during such crisis times, the particular sharp decrease of the inflation risk premium may have been partially affected by dislocations in the TIPS market (e.g. Huebscher, 2009). The unwinding of Lehman's portfolio after its bankruptcy caused a sharp increase in TIPS yields, which, in turn, contributed to the sharp decrease in the inflation risk premium.

4.3 Real Rates

Given liquidity premium estimates, we can now identify real rates. In Table 5, we report the statistical properties of real yields. Real rates have been unusually low during this sample period, being negative (in the UK and US) or close to zero (in France) (note again that unconditional levels are not exactly identified, given that the level of the liquidity premium is not pinned down). Real rates dropped steeply over the sample period, being on average in the 61 to 85 basis points range for the first sample period, while being robustly negative in the second (about -90 basis points for the US and France, -2.24% for the UK). This decrease is statistically significant.

The volatility of real rates decreased slightly from the first to the second sample period for the US and France (by about 10 to 20 basis points) but plummeted from 1.21% to 44 basis points in the UK. Overall, real rates are highly correlated across countries (correlations between 0.75 for the US and France and 0.90 for the US and UK). When viewed over the two sample periods, correlations decreased everywhere, mildly so for the US and the UK, but more steeply for the correlations between French real rates and those of the US and the UK. These correlations are now quite low at -0.08 and 0.37, respectively. The correlation decrease cannot be fully attributed to a decrease in volatility as the beta with respect to US rates is also lower and significantly so in the second subsample for both France and the UK. Figure 3 illustrates these patterns. Overall, cleansing inflation-linked yields from the effects of liquidity premiums does not change the properties of real yields all that much (compare Table 5, with Table 1, right panel).

4.4 Variance Decompositions

With all the components identified, we now determine their contribution to the observed yield variation. We begin with nominal yields. In Table 6 (Panel A), we show variance decompositions of nominal yield variation into the variation of its three components. To keep the decompositions simple, we report $\frac{Cov(\text{component}_i,\text{nominal yield})}{Var(\text{nominal yield})}$, for $i =$real yield, expected inflation, and inflation risk premium, respectively. This assigns the covariance terms equally to the three components and the three components add to 100%. The main message is that real yield variation is the dominant component of the yield variation for all three countries and both sample periods. The exact magnitude, the variation over time and what other components are important varies across countries.

For France, real yield variation accounts for about 79% of nominal yield variation in the first sample period, 60.5% in the second, and 74% overall. The remainder is mostly accounted for by the inflation risk premium, with expected inflation accounting for less than 1.5% of the total variation. For the UK, real yield variation accounts for about 110% of nominal yield variation in the first sample period, 69% in the second, and 107.5% overall. Ratios above 100% occur when there are other, negative covariance contributions, and for the UK real yields and expected inflation are negatively correlated. A negative correlation between real yields and expected inflation is inconsistent with activist monetary policy, but during our sample may be partially driven by longer term offsetting trends in expected inflation (up) and real yields (down). The contribution of the inflation risk premium is positive overall and in the second sample, where it exceeds 37%. It is negative in the first subsample, because the correlation between the inflation risk premium and real yields was negative during that sample period. As a result, expected inflation provides a negative contribution to the total nominal yield variation in all three UK samples.

For the US, real yield variation accounts for about 65% of nominal yield variation in the first sample period, a whopping 113% in the second, and 77% overall. The contribution of expected inflation is larger overall than in the other countries, but still smallish at 4.22%. In the first subsample it increases to 6.88%, but it is negative in the second subsample, mostly driven by a correlation between real yields and expected inflation that turns negative in that period. The inflation risk premium accounts for about 18% of the total nominal yield variation over the full sample, a share that is over 28% in the first sample period but becomes negative in the second period. Even though real yields and inflation risk premiums decreased over time, they show a positive covariation in the first sample period but a negative covariation in the second subsample resulting in the negative contribution of the inflation risk premium to nominal yield variation.

We can do a similar decomposition for inflation-linked yields, splitting them in real yields and liquidity premiums. The results are in Table 6, Panel B. Again, real yields dominate, accounting for between 77% and 125% of the total variation of inflation-linked yields. The numbers are often above 1, because the covariance between liquidity premiums and real yields is mostly negative.

4.5 Comovement Decompositions

In Table 7, we report a decomposition of the international correlation between nominal yields. Recall that these correlations were generally high, but decreased in the second part of the sample, with the decrease particularly dramatic for the French - US correlation. Because the nominal yield has three components, there would be nine components in a full correlation decomposition. We therefore report a simpler decomposition, analogous to the one reported for the variance. We compute the covariance with the three components of the nominal yield in one country with the nominal yield in the other country, but scale all of them by the product of the nominal yield standard deviations so that the 3 numbers sum to the total correlation. We can do this decomposition from the perspective of the two countries, but they provide a clear picture of what component dominates the correlation. Overwhelmingly, it is the covariance between real yields across countries that constitutes the most important component of the total correlation. This is always true over the full sample with the real yield covariance accounting for 0.69 (French perspective) or 0.93 (UK perspective) of a 0.91 correlation for French-UK nominal yields, for 0.61/0.55 of a 0.79 French-US correlation and for 1.04/0.72 of a 0.95 UK-US correlation. The second most important component is invariably the inflation risk premium with expected inflation providing a miniscular or negative contribution to the total correlation.

For the first subsample, the overall correlation remains positive and the overall result in terms of relative contribution, with real rates dominating followed by inflation risk premiums, mostly holds. The contribution of the inflation risk premium does drop to negligible levels for the France-UK pair (UK perspective) and UK-US pair (UK perspective).

For the second subsample, the results are slightly different. For France and the UK, the real yield dominates comovements (0.47 of 0.57) from the French perspective, but its contribution drops to 0.15 from the UK perspective and it is expected inflation dominating now (0.30 of 0.57). Inflation risk premiums account for about 0.10 of the correlation from both perspectives. Recall that UK expected inflation still shows some volatility in the second subsample (25 basis points), whereas the volatility of its real rates and inflation risk premiums decreased substantially. For France and the US, the nominal yield correlation drops to an insignificant 0.07, rendering the decomposition less meaningful. Moreover, a highly positive covariance between the French real yield and US inflation risk premium is coupled with a very negative correlation between the

French inflation risk premium and the US real yield makes the correlation decompositions very different depending on the country perspective. Again, expected inflation is not important. For the UK-US nominal yield correlation real yield covariances are still dominant in the second subsample, but there is also a large contribution of inflation risk premiums, partially offset by a negative contribution of expected inflation.

Table 7 Panel B investigates the cross-country correlation decompositions of inflation-linked yields. It shows that, as for nominal yields, real yield correlations are the main driver of correlation levels and their time variation. Of course, when the correlation drops to -0.01 between French and US real yields in the second sample, both components deliver contributions of opposite sign, which are reversed depending on the country perspective.

5 A Consumption-based Asset Pricing Model of Real Yields

In this section, we extend the consumption-based asset pricing habit model of Bekaert, Engstrom, and Xing (2009), where expected consumption growth, consumption uncertainty, and risk aversion are state variables driving yields. A distinctive feature of the habit framework (see Campbell and Cochrane, 1999, and many follow-up papers) is stochastic risk aversion which recent evidence suggests to be a priced state variable correlated across countries (see Stathopoulos, 2017, for a theoretical model and Bekaert, Hoerova, and Xu, 2019, for empirical evidence). Moreover, the habit framework has been documented to replicate key properties of the term structure of interest rates better than other models (see Buraschi and Jiltsov, 2007). In addition, Duffee (2018) argues that habit models perform better than alternative equilibrium models in generating substantive news about real rates and expected excess returns so as to match his key finding of inflation news accounting for a small fraction of the variation in nominal yield news.. Our model also features state variables considered important by other asset pricing paradigms, such as expected consumption growth and consumption growth uncertainty. The latter may well play an important role in yield dynamics, given that the various crises the world economy recently witnessed may have induced important precautionary savings effects.

In the first subsection below, we develop our consumption-based asset pricing model. In the second subsection, we discuss how we measure the various state variables suggested by the model. We also introduce the monetary policy stance as an additional state variable. The third subsection brings the model to the data.

5.1 Risk, Uncertainty and Interest Rates

For ease of exposition, we begin by writing down a closed-economy model. Following Campbell and Cochrane (1999), we assume the existence of a representative agent with preferences of the form:

$$E_0[\sum_{t=0}^{\infty} \beta^t \frac{(C_t - H_t)^{1-\gamma} - 1}{1-\gamma}], \tag{5}$$

where C_t is time t consumption and H_t is the exogenous habit stock. Therefore, the local coefficient of relative risk aversion can be shown to be $\gamma \frac{C_t}{(C_t - H_t)}$ where $\frac{(C_t - H_t)}{C_t}$ is the surplus ratio. As the surplus ratio goes to zero, the consumer's risk aversion tends toward infinity. We view the inverse of the surplus ratio as "stochastic risk aversion", which we denote by Q_t, so that local risk aversion is now γQ_t, and $Q_t > 1$. As Q_t changes over time, the representative consumer's "moodiness" changes, which led Bekaert, Engstrom, and Grenadier (2010) to label these types of models as "moody investor economies".

The intertemporal marginal rate of substitution in this model determines the real pricing kernel, which we denote by M_t, the log of which follows:

$$m_{t+1} = \ln \beta - \gamma \Delta c_{t+1} + \gamma \Delta q_{t+1}, \tag{6}$$

where $q_t = \ln Q_t$, β is the usual discount factor, and Δc_{t+1} represents logarithmic consumption growth. To model the pricing kernel, we must specify the dynamics of consumption growth and of q_t, stochastic risk aversion. Starting with Δc_t, we assume:

$$\Delta c_{t+1} = g_t + \sigma_{cc}\sqrt{v_t}\epsilon^c_{t+1}. \tag{7}$$

Here g_t is the conditional mean of consumption growth, and v_t represents consumption uncertainty, making the consumption growth process heteroskedastic. We model these variables below. As to stochastic risk aversion, we assume q_t follows an autoregressive square-root process which is contemporaneously correlated with consumption growth, but also possesses its own innovation:

$$q_{t+1} = \mu_q(1-\phi_{qq}) + \phi_{qq}q_t + \sigma_{qc}\sqrt{v_t}\epsilon^c_{t+1} + \sigma_{qq}\sqrt{q_t}\epsilon^q_{t+1}. \tag{8}$$

In this specification, q_t is not perfectly negatively correlated with consumption growth as it is in Campbell and Cochrane (1999). Recent work by Martin (2017) and Bekaert, Engstrom, and Xu (2019) is consistent with a risk aversion process that is imperfectly correlated with fundamentals and mean-reverts more quickly than a habit process would suggest. In this sense, our preference shock specification is closer in spirit to that of Brandt and Wang (2003) who allow for Q_t to be correlated with other business-cycle factors and inflation. Note that the covariance between q_t and consumption growth and the variance of q_t both depend on v_t. Because consumption uncertainty is cyclical, increasing in recessions, q_t consequently may inherit its cyclical properties.

The consumption uncertainty dynamics are given by:

$$v_{t+1} = \mu_v(1-\phi_{vv}) + \phi_{vv}v_t + \sigma_{vc}\sqrt{v_t}\epsilon^c_{t+1} + \sigma_{vv}\sqrt{v_t}\epsilon^v_{t+1}. \tag{9}$$

We expect the σ_{vc} coefficient to be negative so that consumption uncertainty and consumption growth are negatively correlated. Finally, the expected consumption growth process is modelled as:

$$g_{t+1} = \mu_g(1-\phi_{gg}) + \phi_{gg}g_t + \sigma_{gc}\sqrt{v_t}\epsilon^c_{t+1} + \sigma_{gg}\epsilon^g_{t+1}. \tag{10}$$

The process is persistent and has a homoskedastic innovation but is also correlated with consumption growth, rendering its conditional variance proportional to consumption uncertainty.

There are 4 shocks, $\epsilon_t = [\epsilon_t^c; \epsilon_t^q; \epsilon_t^v; \epsilon_t^g]'$, which are assumed to follow a $\mathcal{N}(0, \mathcal{I})$ distribution. There are three state variables: $X_t = [g_t, q_t, v_t]'$. Because of the Gaussian shock structure, the real term structure implied by the model is affine in the state variables, that is:

$$r_{t,n} = r_{0,n} + r'_{1,n} X_t, \tag{11}$$

where the coefficients are derived in Appendix V. For example, the one-period log-real yield is given by:

$$r_t = \mu_r + \gamma g_t + b_{rv} v_t + b_{rq} q_t, \tag{12}$$

where $b_{rv} = -\frac{1}{2}\gamma^2(\sigma_{cc} - \sigma_{qc})^2$ and $b_{rq} = \gamma(1 - \phi_{qq}) - \frac{1}{2}\gamma^2\sigma_{qq}^2$.

High expected consumption growth increases the real rate, through the usual intertemporal smoothing effect. Consumption uncertainty, v_t, has important term structure effects as it affects the volatility of both consumption growth and q_t, and therefore the volatility of the pricing kernel. The b_{rv} coefficient is unambiguously negative, that is, this state variable generates precautionary savings effects. In times of high economic uncertainty, the representative agent has a higher desire to save; for equilibrium to obtain, interest rates must fall, raising bond prices. Therefore, this variable introduces an economic mechanism for declining interest rates in bad times. However, the b_{rq} coefficient cannot be signed, as the risk aversion variable, q_t, affects the interest rate through offsetting utility smoothing and precautionary savings channels. Wachter (2006) and Bekaert, Engstrom and Xing (2009) find the intertemporal smoothing effect to dominate, while Verdelhan (2010) argues that the precautionary savings effect is stronger. Bekaert, Engstrom, and Grenadier (2010) find that the relative importance of these effects is time-varying.

The model so far does not feature a link between the real side and inflation. This is not difficult to accomplish, but we kept the real model deliberately simple, choosing to create a link between inflation and the real side of the economy through the model of inflation (see below). We also do not model monetary policy explicitly, which would produce a link between real interest rates and expected inflation through the Taylor principle. We come back to modelling monetary policy in section 5.3. Finally, we also do not consider a full international equilibrium, simply assuming a pricing kernel exists in all three countries. To make the model more explicitly internationally, we can think of all state variables consisting out of a global and a local component, with isomorphic dynamics. Instead, we use the actual empirical comovements of the state variables when testing the implications of the model for the stylized facts regarding yield comovements. Because we are not interested in exchange rates, we also do not model the actual goods economy behind the international equilibrium (see Burnside and Graveline, 2019, for some pitfalls in interpreting pure exogenous international pricing kernel models) .

5.2 Measuring the State Variables

Rather than trying to calibrate or estimate the model formally, we seek to find empirical proxies for the various state variables. Because the term structure is affine in the state variables, we then simply use regression analysis to link yields to the state variables. In terms of consumption data, we follow the consumption-based asset pricing literature, and use quarterly real per-capita seasonally adjusted consumption growth of non-durables and services, which we obtain from OECD.Stat for all three countries. For the expected consumption growth series, we use survey data directly. We extract 5 year expected real consumption growth for all three countries from Consensus Economics, but also use their one year forecasts in our analysis.

The computation of the conditional consumption growth variance proxy proceeds as follows. First, we regress realized consumption growth on its two lagged values, and 1 and 5 year ahead survey expected consumption growth. The residual of this regression defines the consumption shock. We then estimate the conditional variance GARCH model of Glosten, Jagannathan, and Runkle (1993) (with one lag) on these residuals. This model allows for negative shocks to have a larger effect on the conditional variance than positive shocks. The conditional variance implied by this model is our proxy for v_t in the model. As a robustness check, we also use a pure projection model, regressing the realized squared consumption growth residuals on their lagged values and allowing different coefficients for positive and negative residual realizations. Our results (available upon request) are robust to this alternative measurement.

Our final state variable is stochastic risk aversion. Under the null that $\sigma_{qq} = 0$, the shocks to risk aversion and consumption growth are perfectly correlated, as is true in the original Campbell and Cochrane (1999) model. For this case, Wachter (2006) computes a proxy to the risk aversion variable using past consumption data; that is $-\sum_{i=0}^{40} 0.97^i \Delta c_{t-i}$, where Δc_t is quarter t consumption growth. The final time-series is scaled to have 0 mean and unit variance. We term this variable "macroeconomic risk aversion".

When σ_{qq} is non-zero, risk aversion features a shock not correlated with consumption growth. While the state variable is latent, we use the average variance premium during the quarter as a proxy. The variance premium is the difference between the VIX squared and the conditional expected variance for the S&P500 index. Bekaert and Hoerova (2016) argue that this measure is closely correlated with risk aversion in standard optimizing models, whereas Bekaert, Engstrom, and Xu (2019) estimate a model in the same class as the model we present in section 5.1 and empirically show that q_t is highly correlated with the equity variance premium. Whereas the VIX is a financial asset price, implicitly derived from options prices, the conditional expected variance must be computed. Here we rely on recent estimates by Bekaert, Hoerova, and Xu (2019), who estimate a series of models for the conditional variance in 7 countries and perform model specification tests. The winning models essentially project the future monthly realized variance onto the past monthly, weekly and daily realized variances (computed using high frequency returns) and the past squared VIX. The model permits potential non-linearities in the coefficients depending on the magnitude of the previous realized variance (or squared VIX), accommodating faster mean reversion when variance shocks are large.

Figure 4 graphs the economic variables. Expected consumption growth dips during the Great Recession in all three countries and then recovers in the UK and the US. In France, growth expectations continue to drop and only start to recover in 2013. The 5 year growth expectations show low frequency movements that may well help capture trends in real yields. Following analogous work on trends in expected inflation by Cieslak and Povala (2015), Bauer and Rudebusch (2019), and Jørgensen (2019) argue that real interest rates exhibit time-varying trend behavior that strongly affects the decompositions of interest rates in expectations hypothesis components and term premiums. Under the null of our model, expected consumption growth is an important potential economic source of such trend behavior. In a lower panel, we also show 5 year minus 1 year expectations, which peak overall in the Great Recession and again in the UK and France in 2012-2013, driven by poor short term growth prospects. Consumption uncertainty and "financial" risk aversion are, not surprisingly, spiky, showing sharp peaks during the Great Recession. This makes them less suitable to capture a persistent level factor in yields, but they may capture variation in slopes.

In contrast, the macroeconomic risk aversion variable is very persistent starting to increase as bad economic shocks accumulate in the Great Recession, and only starts to decline in the UK and US around 2014, as consumption growth starts picking up. In France macro risk aversion remains high at the end of the sample. The low frequency behavior of this variable may help mimic trend behavior in real rates and/or exhibit a strong negative correlation with the monetary policy actions driving down real interest rates in the aftermath of the crisis. It is therefore important to introduce a variable measuring the stance of monetary policy as well. This variable then also constitutes a direct measurement of the "policy channel", stressed as an important source of interest rate comovements across countries in Jotikasthira, Le, and Lundblad (2015). Our discretionary monetary policy measure is the residual of Taylor rule regression (Taylor, 1993), regressing the 1 quarter nominal yield on expected inflation (1 quarter for the US, 1 year for France and the UK, obtained from the same survey dataset from which we obtain our long-term inflation expectations) and the output gaps from Bloomberg for France and the UK and from the Congressional Budget Office for the US. While there is much to do about the "zero lower bound", interest rates in Europe have essentially broken through this bound, and by using the full sample to estimate the relationship, the Taylor residual may actually adequately reflect the stance of monetary policy. It is also possible that the "low for too long" monetary policy interacts with our risk aversion proxies through reaching for yields motives; Berndt and Helwege (2018), for example, argue that recently risk premia are lower for high-yield debt compared to investment-grade debt through such a mechanism. Another channel through which monetary policy may interact with low frequency behavior in risk aversion is the effect of low interest rates on planned retirement income, and of the crisis on elderly unemployment, both perhaps leading to increased risk aversion among the older savers population.[7]

All of our analysis here is conducted quarterly, unless mentioned otherwise, because consumption growth and survey data are available quarterly, but the results are almost identical when conducting the analysis monthly, repeating the quarterly values for all months inside the quarter.

[7] We thank Jean Helwege for suggesting such a channel.

5.3 Linking Real Yields to the Economic State Variables

We now run regressions of the 5 year yields in the three countries on the 5 state variables, computed above. Barring the use of exchange rates, there are no cross-country restrictions we can exploit. The results are reported in Table 8. To gain some intuition, we first report univariate regression results, whereas the last column reports the results from a multivariate regression. The model predicts expected consumption growth to have a positive effect on the real yield (the coefficient is only literally interpretable as the risk aversion coefficient for the one quarter rate). This is borne out for the US and France and the coefficient is quite similar in magnitude (around 2.40) and significant at the 10% level or better. For the consumption variance, we expect a negative effect with precautionary motives dominating, and indeed the coefficient is negative in all three countries, but not statistically significant.

As we discussed before the risk aversion variables can affect yields with either a negative sign or positive sign, depending on whether precautionary motives or intertemporal smoothing dominates. For macroeconomic risk aversion, we find a negative coefficient which is highly statistically significant, varying between about -0.95 (France and the US) and -1.50 in the UK. The R^2 in the regression is very high at 73.50% (US) or more. Financial risk aversion has no significant effect on yields, except in the UK, with the sign not consistent across countries.

Finally, we verify the importance of discretionary monetary policy for yields. This variable has the expected positive sign and is highly statistically significant in the UK and the US, but is insignificant in France. In the US and the UK, the adjusted R^2 of the regression is also quite high at 41% and 38%, respectively.

Specification 6 constitutes the multivariate regression with all 5 variables. First, our explanatory power is in line with macro-finance models such as Ang and Piazessi (2003), with the state variables generating a 78% adjusted R^2 in the US, 85% in France, and 89% in the UK. The key result is that macro-risk aversion enters for all three countries with a negative sign and is statistically significant at the 1% level. For French yields, it is the only statistically significant variable and the adjusted R^2 of the univariate regression is higher than that of the multivariate model. In the UK and the US, discretionary monetary policy is also significant at the 5% level, but its coefficient has decreased from 0.96, respectively 0.60 in the univariate model to 0.35 here. That is, about one third of the monetary policy effect on short rates passes through to 5-year yields. In the UK, financial risk aversion is also statistically significant at the 1% level, with the coefficient being positive.

To aid with the interpretation of the results, we also project the one quarter nominal rate onto our state variables (with results relegated to Appendix VI). Recall that the long rate can be split up in expected future short rates (the expectations hypothesis term) and a term premium. The coefficients on macro risk aversion are also negative but slightly larger in magnitude in the short rate projections, which is consistent with the effect arising from the expectations hypothesis term. For the UK, the financial risk aversion coefficient for the short rate is significantly negative, suggesting that it is the term premium that is positively related to financial risk aversion and causes the sign reversal for the 5 year yield. The negative effect of macroeconomic risk aversion on short rates also persists in a Taylor rule regression on expected inflation and the output gap.

Table 9 investigates the ability of the model to reproduce cross-country real yield correlations - the main driver of time-varying cross-country nominal and inflation-linked correlations in our sample. We study three models focusing on the two most powerful explanatory variables of real yields as revealed in Table 8. In Model 1, real yields are only a function of macroeconomic risk aversion. In Model 2, real yields are only a function of discretionary monetary policy. In Model 3, real yields are a function of both macroeconomic risk aversion and discretionary monetary policy.

To compute yield comovements under the null of the model, we assume that the coefficients on the state variables are constant over time (as in Table 8), as they represent structural parameters. Because all state variables are heteroskedastic, we allow the variances (covariances) of the state variables to vary across the two sub-samples. Thus, changes in correlations can arise from changes in the relative importance of the various state variables through their changing variances, or changes in correlations among the state variables themselves.

In results reported in Appendix VII, we verify how well the various models fit the mean and standard deviation of real rates. Over the full sample, the model perfectly fits the data mean by construction, but under the assumption of constant exposure to the factor, it need not fit the change in means. We find that Models 1 and 3 almost perfectly match the decrease in real rates from subsample 1 to 2. However, Model 2 underestimates the mean in subsample 1 and overestimates the mean in subsample 2. In terms of volatility, models 1 and 3 mostly fit the standard deviations closely, except in the second sub-sample for France and the UK.

Table 9 indicates that Model 1 (macroeconomic risk aversion only) and Model 3 (macroeconomic risk aversion+discretionary monetary policy) are able to replicate high full sample cross-country real yield correlations for all country pairs, the model correlations being well within two standard errors of their data counterparts. However, Model 2 (discretionary monetary policy only) fails to replicate high full sample cross-country correlations between France and the UK (0.09 in the model versus 0.86 in the data) and France and the US (0.22 in the model versus 0.75 in data). Models 1 and 3 also generally generate a drop in correlations between subsample 1 and subsample 2, with Model 1 usually implying a stronger drop. Model 2 fails to replicate the drop in real yields correlations between the US and the UK from subsample 1 to subsample 2 and also often implies correlation values far away from the data counterparts in both subsamples. In contrast, the macroeconomic risk aversion state variable is helpful in fitting cross-country real yield correlations, and Models 1 and 3 generate correlations that are outside a two standard error band around the data correlation in only 1 out of the 9 cases.

We also redo the computations assuming the state variables in each country have a constant beta with respect to the "world" state variable (which is simply the average of the three variables), and the only change across subsamples are the variances of the state variables, consistent with the heteroskedasticity assumed in the model. If anything, this model, using risk aversion as the only state variable, provides a better fit with the data correlations than the models reported in Table 9 (results are available in Appendix VII).

Table 10 investigates the ability of our models to fit real yield variation focusing on variation in inflation-linked yield variances explained by the real rate. We construct the model-implied inflation-linked yield as the sum of the model-implied real yield and our estimated liquidity premium. Table 10 shows that Model 1 (macroeconomic risk aversion only) and Model 3 (macroeconomic risk aversion+discretionary monetary policy) closely replicate the observed variance ratios in the full sample and subsample 1. Model 2 (discretionary monetary policy only) invariably underestimates the real yield variance share. In France and the UK, this undershooting is both economically and statistically significant. In the US, Model 2 still generates a real rate share that is in a two standard error band around its data counterpart but is economically rather far below the data ratio (e.g. in the overall sample, 83.86% of the inflation-linked yield is accounted for by the real rate, but Model 2 can only muster 68%). For the second subsample, all models underestimate real rate variation and fail to generate the persistently high real rate share, underpredicting it in a mostly statistically significant manner. For the UK, model 2 in fact performs better than either model 1 or model 3 in the second subsample.

6 Model-implied Inflation Risk Premiums and Nominal Yields

To price nominal bonds, the usual approach is simply to add an inflation process exogenously to the model and then to use the nominal pricing kernel $m^N_{t+1} = m_{t+1} - \pi_{t+1}$ where π_{t+1} is inflation between time t and $t+1$. We accomplish this task in the first subsection. We investigate empirically the determinants of the inflation risk premium in the second subsection. Given these estimates, we then study model-implied correlations for nominal yields across countries in the third subsection.

6.1 Modeling Inflation

Our inflation model is designed to provide a rich representation of the inflation risk premium. We model one-period (one quarter) inflation as expected inflation plus a shock:

$$\pi_{t+1} = p_t + \sigma_{\pi\pi}\sqrt{w_t}\epsilon^{\pi}_{t+1}. \tag{13}$$

Here, p_t is expected inflation, w_t is inflation uncertainty, and ϵ^{π}_{t+1} is standard Gaussian shock. Both p_t and w_t are persistent and stochastic and therefore the level of inflation is not a state variable in the model, but p_t and w_t are. In particular, p_t follows:

$$p_{t+1} = \mu_p(1-\phi_{pp}) + \phi_{pp}p_t + \sigma_{p\pi}\sqrt{w_t}\epsilon^{\pi}_{t+1} + \sigma_{pq}\sqrt{q_t}\epsilon^{q}_{t+1} + \sigma_{pc}\sqrt{v_t}\epsilon^{c}_{t+1}, \tag{14}$$

Inflation uncertainty affects the uncertainty of expected inflation but expected inflation is also affected by consumption growth shocks and by risk aversion shocks. The σ_{pq} coefficient governs the correlation between risk aversion and expected inflation. Brandt and Wang (2003) explicitly model stochastic risk aversion as a function of inflation, surmising that high inflation goes hand in hand with high risk aversion. It seems prudent to not impose strong priors here. The correlation between expected inflation and consumption shocks is related to a large literature on Aggregate Supply (AS) versus Aggregate Demand (AD) environments. In an AD environment, (expected) inflation and growth shocks move in the same direction, in an AS environment they move in the opposite direction. The σ_{pc} coefficient being positive (negative) suggests an AD (AS) environment. Ideally, the model endogenously allows switches between the to regimes, but this is difficult to accomplish (see, e.g, Campbell, Pflueger, and Viceira, 2018, Song, 2017, or Bekaert, Engstrom and Ermolov, 2018).

To model inflation uncertainty, we use a similar model:

$$w_{t+1} = \mu_w(1 - \phi_{ww}) + \phi_{ww} w_t + \sigma_{w\pi}\sqrt{w_t}\epsilon^{\pi}_{t+1} + \sigma_{wv}\sqrt{v_t}\epsilon^{v}_{t+1}, \tag{15}$$

We do not use new shocks but assure there is correlation between inflation shocks and inflation uncertainty shocks (perhaps, it is natural to assume $\sigma_{w\pi} > 0$), and between inflation and consumption uncertainty shocks. It is conceivable that σ_{wv} is positive, making real and nominal uncertainty positively correlated. It is easy to see that apart from a Jensen's inequality term, the nominal short rate follows the Fisher hypothesis. That is, we have imposed the popular assumption that the inflation risk premium is zero (or at least small) at short horizons.

In this model the inflation risk premium depends on v_t, q_t, and w_t. Appendix V derives the inflation risk premium for a two period bond, as an example. The coefficient on q_t inherits the sign of σ_{pq}; the coefficient on v_t is likely negative if σ_{pc} is positive. This makes economic sense: in an AD environment, real uncertainty depresses real yields and inflation risk premiums simultaneously. The coefficient on w_t (inflation uncertainty) cannot be signed. More generally, whereas real yields depend on three state variables (g_t, v_t, and q_t), nominal yields depend on two additional state variables, namely p_t and w_t, whereas the inflation risk premium depends on the uncertainty and risk aversion state variables.

6.2 Economic Determinants of the Inflation Risk Premium

To bring the model to the data, we need a proxy for inflation uncertainty. Our primary variable is the conditional variance of expected inflation. For the US we use 1 quarter expected inflation; for the UK and France, we assume that 1 quarter expected inflation is equal to 1 year ahead expected inflation (since 1 quarter ahead inflation surveys are not available for these countries). We construct expected inflation shocks by estimating AR(1) models for these survey expected inflation series. We estimate a GJR-GARCH model on the residuals of these AR(1) models to get the conditional expected inflation variance. Our results using GJR-GARCH variance estimates from residual inflation shocks (available upon request) computed as realized minus expected inflation are similar.

We add two variables that are outside the model. First, we include the discretionary monetary policy variable to ensure that we control for the unusual monetary policies during the sample period, which may have had an effect on inflation uncertainty. Second, in our model the correlation between expected inflation and consumption growth is assumed constant. When viewed over a long time period, this covariance should vary over time (Burkhardt and Hasseltoft, 2012; Ermolov, 2015; Campbell, Sunderam, and Viceira, 2017; Song, 2017). We therefore add a state variable capturing potential time-varying correlation between consumption growth and expected inflation. We use the consumption growth residuals described above in constructing the conditional consumption growth variance and expected inflation residuals described above in constructing the expected inflation variance. We then estimate the conditional covariance between the expected inflation and consumption growth residuals using the dynamic conditional correlation-model of Engle (2002). Details of the estimation are relegated to Appendix VIII.

Table 11 has the same format as Table 8. The new inflation-specific variables, inflation uncertainty and the conditional covariance between inflation and consumption growth, are never significant, neither in the univariate, nor in the multivariate regressions. Of the state variables that also affect real yields, we again find that macroeconomic risk aversion has a negative effect on inflation risk premiums, which is significant in all three univariate regressions at the 10% level or lower. Similarly, the coefficient on financial risk aversion is negative in all three countries, but only significant (at the 5% level) in the US and the UK. This reveals another potential reason for these risk aversion measures to affect nominal yields. They may reflect flight-to-safety effects. While standard models tend to generate flight to quality/safety effects through precautionary savings desires induced by consumption uncertainty, a model with stochastic risk aversion can generate such flights to quality or safety through changes in risk aversion. For this effect to work in our model, we need $\sigma_{pq} < 0$: positive risk aversion shocks must decrease inflation expectations.

For the UK, we also find the effect of the consumption growth variance on the inflation risk premium to be positive, which may simply reflect a positive covariance between real and nominal uncertainty. Discretionary monetary policy enters with a positive coefficient but is only significant for the UK in the univariate regressions. In the multivariate regression, this variable is only significant for the US. In these multivariate regressions, financial risk aversion is statistically significant in all three countries; macroeconomic risk aversion is significant in France and the UK only, with all these coefficients negative. The adjusted R^2's in these regressions is considerably lower than what we observed for real yields.

6.3 Fitting Nominal Yield (Co)variances

From the estimates of the inflation risk premium and the real yield and using survey expected inflation, we can reconstruct nominal yields. The real yield model is the one factor model with macroeconomic risk aversion as the only state variable; the inflation model has three factors, namely macroeconomic risk aversion, financial risk aversion and discretionary monetary policy; the variables that were significant in at least two countries in the multivariate specification. Similar to real yields, we first verify the model's fit with observed averages and standard deviations. In Appendix VII, we show that the model generates lower nominal yields for the second subsample for all three countries as is true in the data. It also predicts steeply falling standard deviations, which is consistent with the data, except in France where the standard deviation actually increases.

In Table 12, we show cross-country correlations of nominal yields for the data and the model. The model replicates the correlations for the full sample and the first subsample rather well for all three countries, but it exaggerates the drop in correlations in the second subsample, leading to correlations below the two standard error band for the France-UK, UK-US pairs.

In Table 13 we verify whether the model replicates that real yields are the dominant force in accounting for variation in nominal yields. In the model, as in the data, it is true that real rates mostly account for a dominant fraction of the total variance of the nominal rate. In the majority of the cases, the model slightly underpredicts the dominance of real rates, but in one instance for the UK in the second sub sample, the model far exceeds the observed contribution of the real rate variation. For the real rate fraction this is the only number not within a two standard error bound around the data number. The fit with expected inflation and inflation risk premium ratios is generally satisfactory except for the subsamples in the UK, especially the second subsample, as the mirror image of the overfitting of the real rate variance. However, the model also exaggerates the contribution of the inflation risk premium in the first subsample.

7 Extensions

In this section, we consider two extensions of our analysis. First, we redo all the analysis using slopes rather than levels. Second, we expand our sample of countries to include Germany, Australia and Sweden (over a shorter sample period).

7.1 Evidence for Slopes

Slopes over a very short time period may be more informative about the economic sources driving interest rates, especially when interest rates show non-stationary behavior. For example, if the short-term interest rate follows a driftless random walk, the term spread equals the term premium. More generally, the large changes observed in the means of nominal and inflation-linked interest rates across subsamples may not affect spreads as strongly.

We replicate all our earlier work on levels for slopes. Our measure of the nominal term spread is simply the 5-year yield minus the one quarter Treasury bill rate. Furthermore, we assume that the one quarter nominal yield equals the real yield plus one quarter expected inflation, where the latter is measured from survey data. That is, we assume the Fisher hypothesis holds at the one quarter horizon, rendering the inflation and liquidity risk premiums zero at the one quarter horizon.

Table 14 provides a summary. We provide results only for the nominal slopes, computed from the data, and the real slopes, which follow from correcting the inflation-linked slopes for the liquidity premium. First, we show the usual statistical properties in terms of averages, standard deviations and correlations. It is indeed the case that neither nominal nor real slopes show significant changes in means over the two subsamples, although the real slopes increase by about 20 to 50 basis points in the three countries in the second subsample. We do observe that the standard deviations of both nominal and real slopes decreased over time, and mostly in a statistically significant fashion. As with interest rate levels, nominal slopes are highly correlated across countries, but real interest rate slopes are less correlated (with the correlations varying between 25% and 75%). Almost invariably, the slope correlations decrease over time, mostly in a statistically significant fashion. Real slope correlations between the European countries and the US are negative in the second subsample.

We also show how much our derived real slopes contribute to the variance of the nominal and inflation-linked slopes. We confirm our main result for levels: the real slope dominates. In France, it accounts for about 78% of the total nominal slope variance, with scant variation over subsamples. In the UK, the real rate slope contribution is also about 78% over the full sample but increases from 72 to slightly over 100% over the two subsamples. In the US, the real rate slope contribution exceeds 90% in all samples. The real rate slope also dominates inflation-linked yield slopes, with its contribution being never lower than 63%, which occurs for the UK in the first subsample. It exceeds 100% for the US in the second subsample.

We further conduct the international correlation decomposition finding, as we did for levels, that the real part of the nominal slope dominates overall correlations over the full sample. For the France-US pair, the contribution of the expected inflation slope is close to that of the real slope, however. The dominance of the real yield slope continues to hold for the correlations of inflation-linked slopes across countries.

Finally, we estimate the term structure model for slopes, but relegate the results and corresponding discussion to Appendix IX. Risk aversion proxies continue to play a relatively important role in term spread dynamics, but only in the US and the UK.

7.2 Additional International Evidence

Many inflation-linked debt markets have relative short histories and/or an insufficient number of bonds to reliably compute zero coupon bonds in the early stages of their development (see Ermolov, 2018 for more details). To expand our sample internationally to Germany, Sweden and Australia, we are forced to start the sample later, in 2011. Recall that this roughly coincides with our earlier second subsample during which, for example, correlations between yields had decreased. Nonetheless, we can still verify whether our main result, namely, the dominance of real rate variation, holds up for the more extensive sample. The results are reported in Table 15. Note that we identify liquidity premiums in the three new countries separately as we could not assemble a consistent set of liquidity proxies for all three countries. Full details on the identification of these liquidity premiums and other data inputs is provided in Appendix X. First, we confirm for these countries that the bulk of nominal yield variation derives from the real rate, which accounts for 61% of nominal yield variation in Germany, 71% in Australia and 76% in Sweden. The remainder is mostly accounted for by the inflation risk premium. Second, nominal yields are generally highly correlated, with one important exception. US yields, during this more recent period, show little or no correlation with the yields of these other countries. All other correlations vary between 0.49 (Germany and Sweden) and 0.96 (France and Germany). While the latter high correlation is not surprising, note that Australian and German yields are also 0.95 correlated. Overwhelmingly, the correlation decomposition shows the real rate to be the main variable behind these high correlations, but there are a few exceptions, such as expected inflation playing a larger role for the Australia-UK, Germany-UK and Sweden-UK correlations (from the UK perspective).

8 Conclusion

We reconsider an important decomposition of nominal bond yields into its real and inflation components in an international context, focusing on the US, UK, and France. We study a relatively short period, starting in 2004, because we want to alleviate the identification problem in the decomposition by using inflation-linked debt. With this period dominated by unusual monetary policies, we primarily focus on the 5 year yield, rather than short term rates. The key finding relative to earlier work is that the roles of expected inflation and real rates have changed. Inflation expectations show little variation and thus variance and cross-country co-movement decompositions show that expected inflation accounts for little of the variation in nominal yields.

The real rate can be extracted from inflation-linked debt by removing a liquidity risk premium. Yet, real rate variation dominates the variation in inflation-linked yields. With stable inflation expectations, and moderately variable inflation risk premiums, real rate variation also dominates the variation in nominal yields. Real rates correlate highly across countries for most of the sample period, but more recently the correlations have decreased substantially. The dominance of the real rate in driving variation of observed yields and international yield correlations extends to a shorter time series sample, including data from Australia, Germany, and Sweden.

Economic intuition would suggest that real rates might be highly correlated across countries, jointly reacting to world business cycles, for example. However, we do not find much direct evidence of this. We formulate a simple habit model where real yields are driven by expected consumption growth, consumption uncertainty and a stochastic risk aversion variable. We find that the risk aversion variable, when constructed consistent with Campbell and Cochrane's (1999) habit model, is the only state variable that both explains a substantive part of the variation in real yields and helps to explain the change in the cross-country yield correlations. It explains more of the variation in real yields and their co-movements across countries than does a measure of the monetary policy stance.

We do not fully exploit all the possibilities of the model. Consumption uncertainty and risk aversion should be important drivers of real term premiums, perhaps more so than of levels of interest rates. Examining the (changes in the) correlation of term premiums across countries would be interesting. To compute term premiums, we need short rate forecasts, but no survey forecasts fully cover our sample period.

Analogously, we could examine deviations from the expectations hypothesis using the model and examine bond returns. Xu (2019) shows that bond returns in the G7 countries exhibit relatively small correlation across countries, but that the correlation varies substantially through time, mostly because of different exposures to a global risk aversion variable. Our model is ideally suited to examine these empirical facts further.

Finally, it must be stressed again that we examine a short sample period. If the data are stationary, then a better approach to use the model is to calibrate it using longer-term data. We could still use inflation-linked debt but would also use inflation and nominal yield data going back further in time. The longer data set would allow us to make inferences not only about variances but also about long-term means. However, it would impose strong stationarity assumptions through time that may not hold.

To somewhat mitigate the stationarity problem, we also examine variance decomposition and correlation dynamics for 5 year-one quarter term spreads, which do not show trending behavior. Consistent with the slope being more driven by the term premium component in interest rates, we now find that financial risk aversion is an important determinant of the real terms spread. Importantly, we once again confirm the dominance of the real rate spread variation in driving yield variation and correlations across countries.

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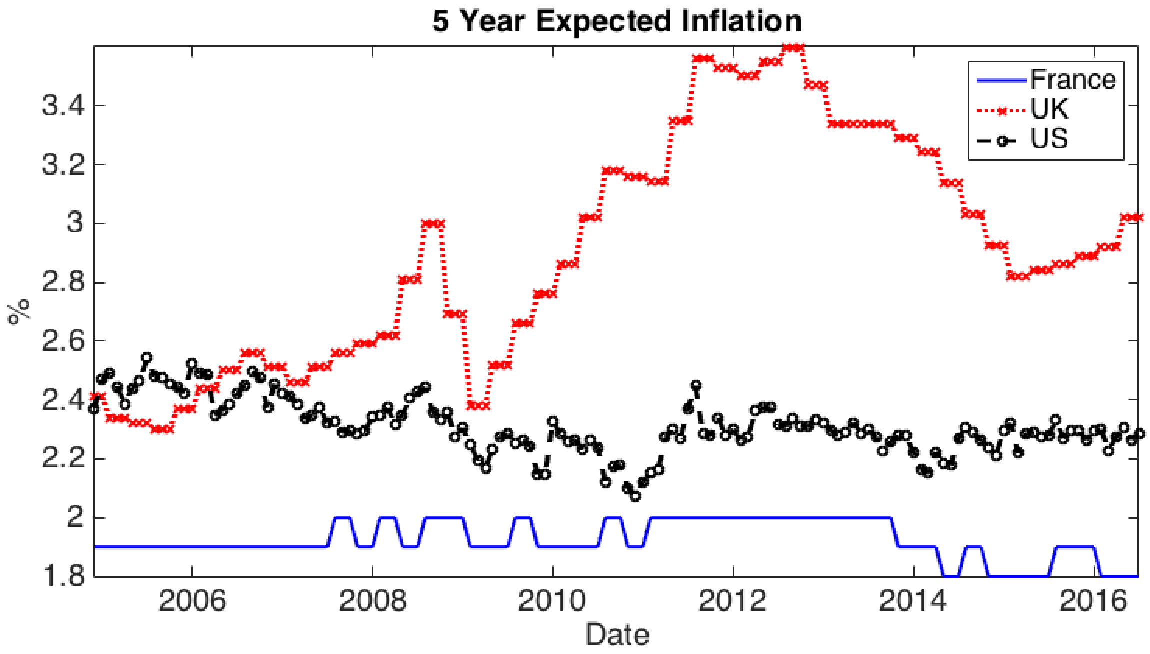


Figure 1 – Annualized 5 Year Survey Expected Inflation.

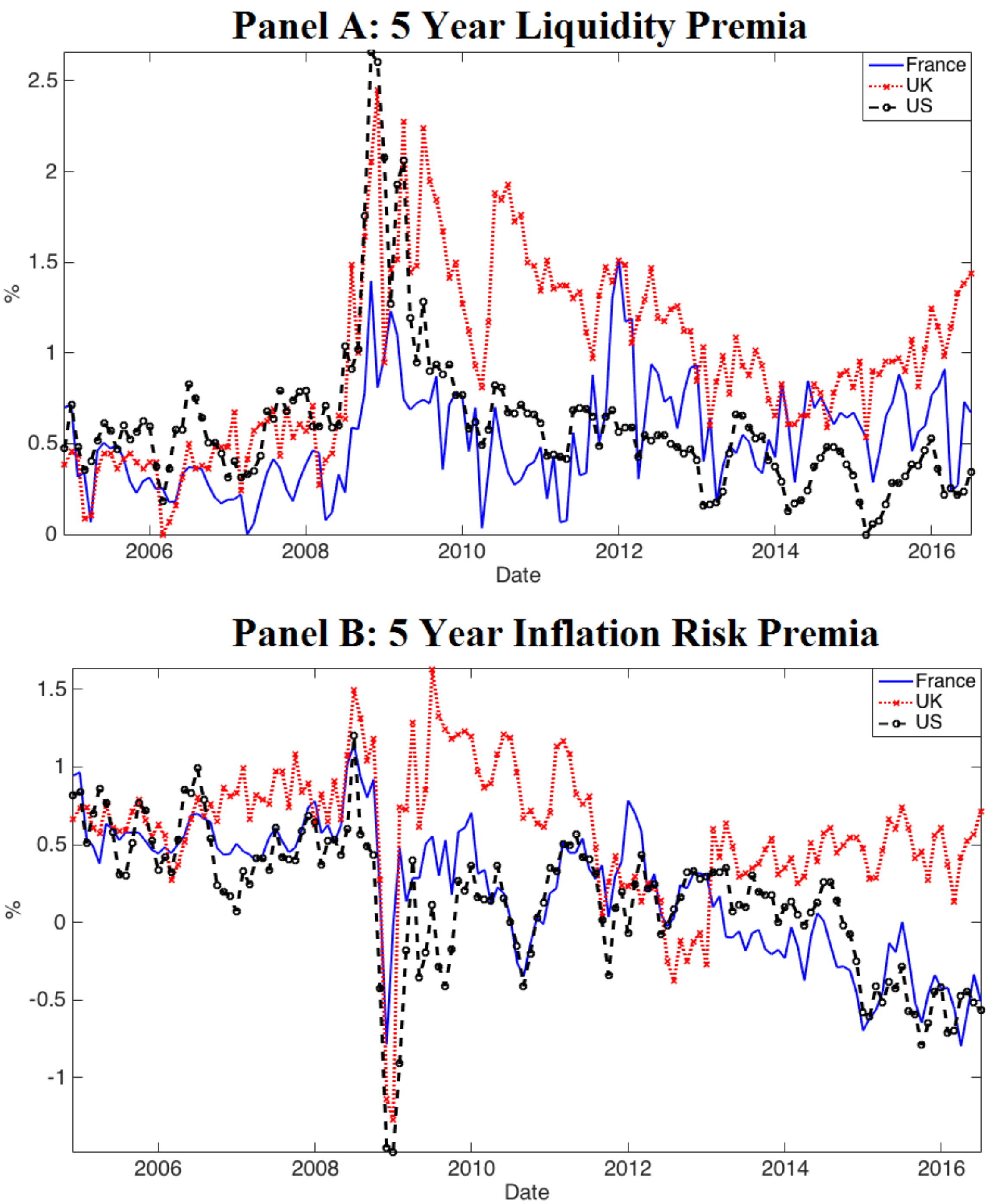


Figure 2 – Annualized 5 Year Zero-Coupon Liquidity and Inflation Risk Premia.

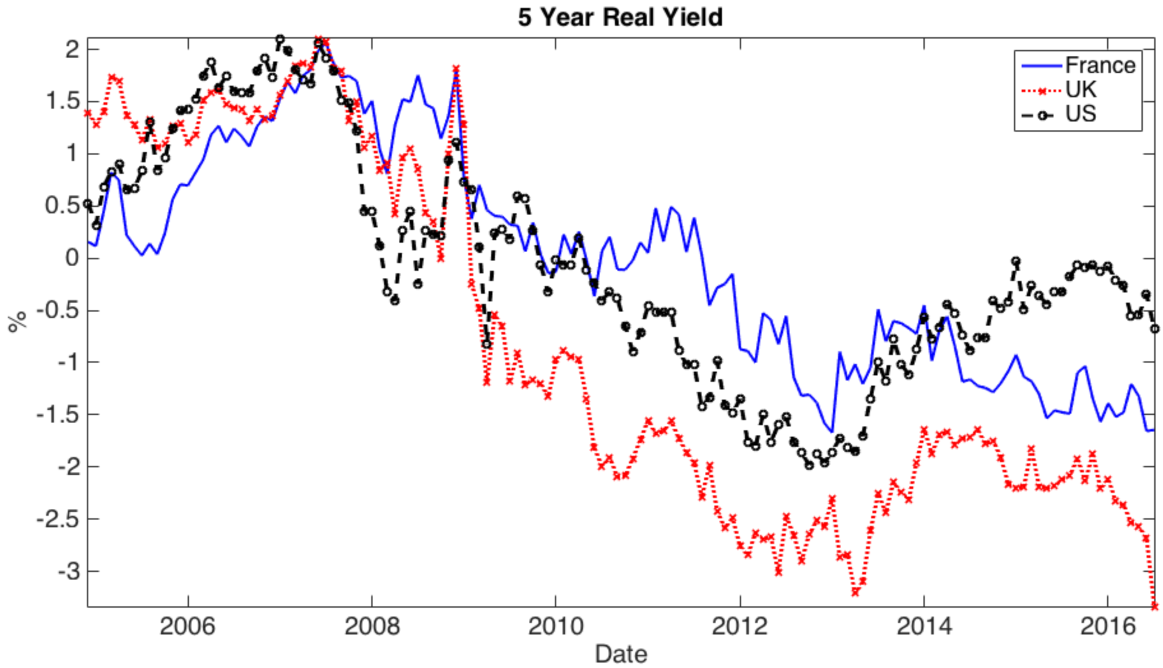


Figure 3 – Annualized 5 Year Real Yields.

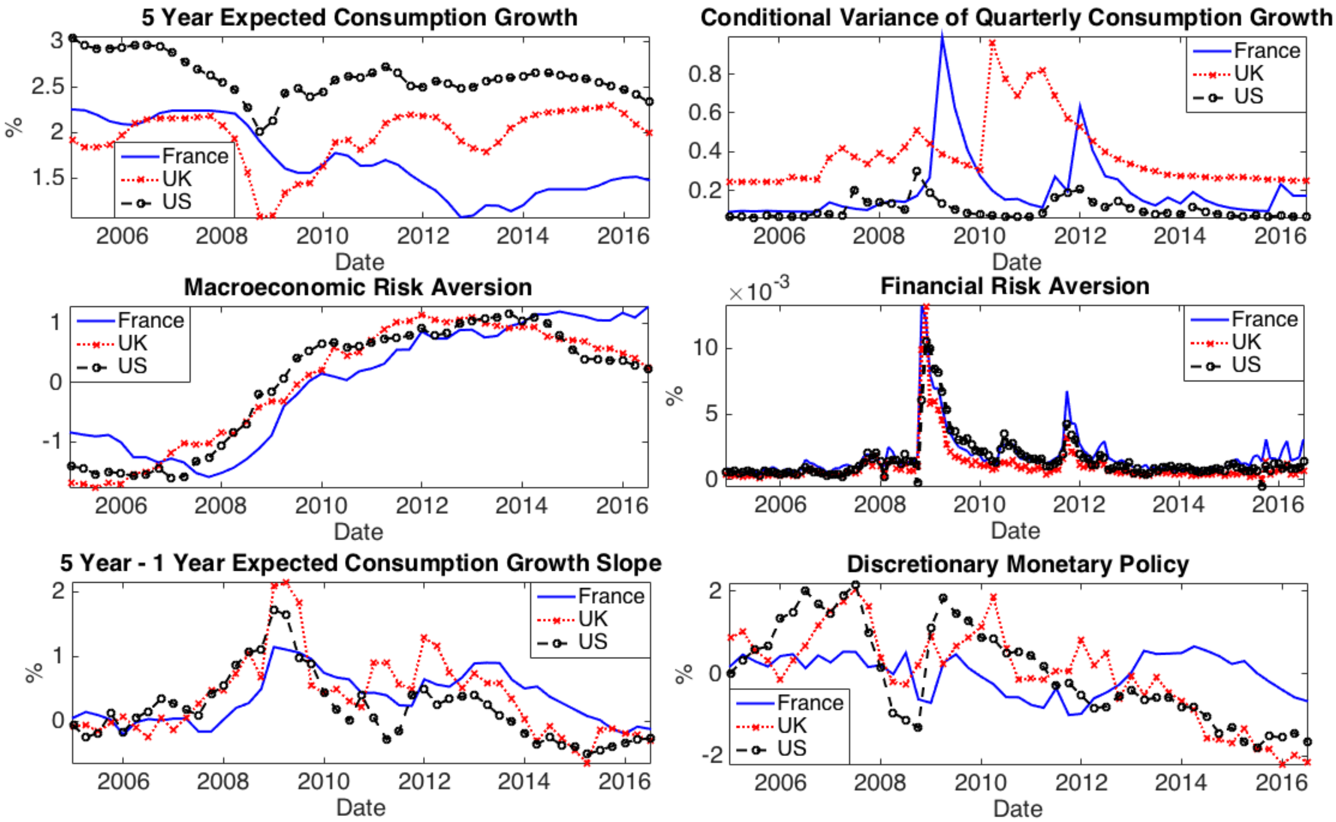


Figure 4 – Economic Variables.

Table 1 – Annualized 5 Year Observed Zero-Coupon Bond Yields. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Nominal yields			Inflation-linked yields		
	France	UK	US	France	UK	US
Average	2.14%	2.69%	2.39%	0.52%	0.15%	0.54%
	(0.43%)	(0.46%)	(0.40%)	(0.30%)	(0.45%)	(0.38%)
Standard deviation	1.39%	1.52%	1.32%	0.96%	1.48%	1.23%
	(0.14%)	(0.14%)	(0.15%)	(0.12%)	(0.10%)	(0.11%)
β wrt US	0.83	1.09	1.00	0.63	1.12	1.00
	(0.14)	(0.09)		(0.09)	(0.06)	
Correlation with US	0.79	0.95	1.00	0.81	0.93	1.00
	(0.13)	(0.08)		(0.11)	(0.05)	
Correlation with UK	0.91	1.00	0.95	0.90	1.00	0.93
	(0.11)		(0.08)	(0.10)		(0.05)
Subsample 1: 2004M11-2010M8						
	Nominal yields			Inflation-linked yields		
	France	UK	US	France	UK	US
Average	3.25%	3.99%	3.44%	1.30%	1.46%	1.57%
	(0.32%)	(0.42%)	(0.47%)	(0.23%)	(0.32%)	(0.26%)
Standard deviation	0.78%	0.97%	1.05%	0.61%	0.84%	0.78%
	(0.14%)	(0.15%)	(0.11%)	(0.10%)	(0.12%)	(0.09%)
β wrt US	0.46	0.80	1.00	0.53	0.88	1.00
	(0.14)	(0.13)		(0.11)	(0.17)	
Correlation with US	0.61	0.87	1.00	0.67	0.81	1.00
	(0.19)	(0.14)		(0.14)	(0.16)	
Correlation with UK	0.86	1.00	0.87	0.75	1.00	0.81
	(0.10)		(0.14)	(0.08)		(0.16)
Subsample 2: 2010M9-2016M6						
	Nominal yields			Inflation-linked yields		
	France	UK	US	France	UK	US
Average	1.02%***	1.39%***	1.34%***	-0.25%***	-1.17%***	-0.49%***
	(0.31%)	(0.15%)	(0.15%)	(0.18%)	(0.11%)	(0.23%)
Standard deviation	0.87%	0.54%	0.41%	0.54%	0.45%	0.55%
	(0.13%)	(0.07%)	(0.13%)	(0.13%)	(0.10%)	(0.16%)
β wrt US	0.15	1.04	1.00	-0.01**	0.49*	1.00
	(0.56)	(0.14)		(0.25)	(0.16)	
Correlation with US	0.07*	0.80	1.00	-0.01**	0.61	1.00
	(0.27)	(0.11)		(0.26)	(0.20)	
Correlation with UK	0.57	1.00	0.80	0.57	1.00	0.61
	(0.24)		(0.11)	(0.12)		(0.20)

Table 2 – Annualized 5 Year Survey Expected Inflation and Nominal Debt Premium. Data is monthly. The nominal debt premium is defined as the difference between nominal yields and the sum of expected inflation and inflation-linked yields. GMM standard errors computed using 12 Newey-West (1987) lags are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Expected inflation			Nominal debt premium		
	France	UK	US	France	UK	US
Average	1.92%	2.90%	2.31%	-0.31%	-0.36%	-0.46%
	(0.02%)	(0.11%)	(0.02%)	(0.14%)	(0.15%)	(0.15%)
Standard deviation	0.07%	0.39%	0.09%	0.54%	0.63%	0.65%
	(0.10%)	(0.13%)	(0.09%)	(0.11%)	(0.07%)	(0.09%)
β wrt US	0.02	-1.83	1.00	0.48	0.68	1.00
	(0.09)	(0.63)		(0.14)	(0.08)	
Correlation with US	0.02	-0.44	1.00	0.58	0.70	1.00
	(0.13)	(0.15)		(0.17)	(0.08)	
Correlation with UK	0.40	1.00	-0.44	0.70	1.00	0.70
	(0.13)		(0.15)	(0.11)		(0.08)
Subsample 1: 2004M11-2010M8						
	Expected inflation			Nominal debt premium		
	France	UK	US	France	UK	US
Average	1.92%	2.59%	2.35%	0.03%	-0.07%	-0.48%
	(0.01%)	(0.07%)	(0.04%)	(0.15%)	(0.23%)	(0.30%)
Standard deviation	0.04%	0.22%	0.10%	0.44%	0.70%	0.87%
	(0.05%)	(0.14%)	(0.12%)	(0.13%)	(0.10%)	(0.13%)
β wrt US	-0.13	-1.22	1.00	0.45	0.76	1.00
	(0.05)	(0.56)		(0.03)	(0.03)	
Correlation with US	-0.29	-0.54	1.00	0.89	0.94	1.00
	(0.11)	(0.25)		(0.05)	(0.04)	
Correlation with UK	0.43	1.00	-0.54	0.91	1.00	0.94
	(0.16)		(0.25)	(0.05)		(0.04)
Subsample 2: 2010M9-2016M6						
	Expected inflation			Nominal debt premium		
	France	UK	US	France	UK	US
Average	1.92%	3.21%***	2.27%**	-0.66%***	-0.65%**	-0.44%
	(0.04%)	(0.12%)	(0.01%)	(0.12%)	(0.15%)	(0.11%)
Standard deviation	0.08%***	0.25%	0.07%	0.39%	0.38%	0.33%
	(0.11%)	(0.17%)	(0.06%)	(0.08%)	(0.16%)	(0.11%)
β wrt US	0.34**	1.13**	1.00	0.82**	0.24**	1.00
	(0.21)	(0.67)		(0.16)	(0.19)	
Correlation with US	0.27**	0.29**	1.00	0.68	0.20***	1.00
	(0.16)	(0.17)		(0.13)	(0.16)	
Correlation with UK	0.82**	1.00	0.29**	-0.03***	1.00	0.20***
	(0.07)		(0.17)	(0.14)		(0.16)

Table 3 – Inflation-linked Bonds Liquidity Premia Estimation. The data is monthly. The panel regression is $y_{t,i} - y^{\mathrm{IL}}_{t,i} - \pi^e_{t,i} = c_{1,i} + c_2' l_{t,i} + \epsilon_{t,i}$, where $y_{t,i}$ is zero-coupon yield in country i at time t, π^e_t is expected inflation, and l_t is the vector of liquidity proxies, which are assumed to be uncorrelated with the inflation risk premium, and $\epsilon_{t,i}$ is the error term. Regressions are for 5 year zero-coupon yields. Newey-West (1987) standard errors computed with 12 lags are in parentheses. Asterisks *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6	Spec 7	Spec 8	Spec 9	Spec 10
Off-the-run premium	-3.53***	-2.49***							-0.08	
	(0.41)	(0.38)							(0.30)	
Inflation swap spread			-1.53***	-1.64***					-1.72***	-1.73***
			(0.09)	(0.07)					(0.08)	(0.08)
Log(share of inflation-linked debt)					0.26***	1.10***			0.61***	0.63***
					(0.08)	(0.22)			(0.14)	(0.14)
Log(months since inception)							-0.26	-1.22***	-1.05***	-1.05***
							(0.19)	(0.11)	(0.12)	(0.13)
Country-fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes
Adjusted R^2	13.61%	31.69%	39.93%	65.18%	2.01%	5.42%	1.73%	23.09%	67.47%	67.55%

Table 4 – Annualized 5 Year Zero-Coupon Liquidity and Inflation Risk Premia. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.53%	0.96%	0.60%	0.21%	0.60%	0.14%
	(0.06%)	(0.13%)	(0.11%)	(0.11%)	(0.09%)	(0.10%)
Standard deviation	0.29%	0.50%	0.41%	0.42%	0.42%	0.45%
	(0.07%)	(0.09%)	(0.10%)	(0.10%)	(0.08%)	(0.09%)
β wrt US	0.25	0.60	1.00	0.71	0.38	1.00
	(0.06)	(0.10)		(0.13)	(0.15)	
Correlation with US	0.35	0.50	1.00	0.76	0.41	1.00
	(0.09)	(0.08)		(0.14)	(0.16)	
Correlation with UK	0.47	1.00	0.50	0.43	1.00	0.41
	(0.14)		(0.08)	(0.13)		(0.16)
Subsample 1: 2004M11-2010M8						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.45%	0.86%	0.78%	0.48%	0.79%	0.30%
	(0.10%)	(0.25%)	(0.18%)	(0.07%)	(0.09%)	(0.14%)
Standard deviation	0.29%	0.63%	0.49%	0.30%	0.44%	0.48%
	(0.11%)	(0.12%)	(0.13%)	(0.10%)	(0.10%)	(0.12%)
β wrt US	0.43	0.89	1.00	0.46	0.41	1.00
	(0.04)	(0.14)		(0.08)	(0.28)	
Correlation with US	0.75	0.70	1.00	0.73	0.45	1.00
	(0.07)	(0.11)		(0.13)	(0.31)	
Correlation with UK	0.66	1.00	0.70	0.44	1.00	0.45
	(0.14)		(0.11)	(0.20)		(0.31)
Subsample 2: 2010M9-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.60%	1.07%	0.42%**	-0.05%**	0.42%***	-0.02%*
	(0.05%)	(0.10%)	(0.05%)	(0.14%)	(0.08%)	(0.14%)
Standard deviation	0.28%	0.28%***	0.18%	0.36%	0.30%	0.36%
	(0.12%)	(0.08%)	(0.07%)	(0.12%)	(0.12%)	(0.17%)
β wrt US	0.25	0.88	1.00	0.78***	0.03	1.00
	(0.27)	(0.19)		(0.08)	(0.21)	
Correlation with US	0.18***	0.56	1.00	0.78	0.03	1.00
	(0.18)	(0.12)		(0.08)	(0.24)	
Correlation with UK	0.02**	1.00	0.56	-0.06	1.00	0.03
	(0.23)		(0.12)	(0.24)		(0.24)

Table 5 – Annualized 5 Year Zero-Coupon Real Yields. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6			
	France	UK	US
Average	-0.00%	-0.81%	-0.06%
	(0.33%)	(0.51%)	(0.34%)
Standard deviation	1.06%	1.69%	1.10%
	(0.13%)	(0.13%)	(0.14%)
β wrt US	0.72	1.38	1.00
	(0.09)	(0.09)	
Correlation with US	0.75	0.90	1.00
	(0.10)	(0.06)	
Correlation with UK	0.86	1.00	0.90
	(0.12)		(0.06)
Subsample 1: 2004M11-2010M8			
	France	UK	US
Average	0.85%	0.61%	0.79%
	(0.27%)	(0.52%)	(0.33%)
Standard deviation	0.66%	1.21%	0.78%
	(0.14%)	(0.18%)	(0.10%)
β wrt US	0.49	1.20	1.00
	(0.17)	(0.28)	
Correlation with US	0.58	0.78	1.00
	(0.20)	(0.18)	
Correlation with UK	0.68	1.00	0.78
	(0.16)		(0.18)
Subsample 2: 2010M9-2016M6			
	France	UK	US
Average	-0.85%***	-2.24%***	-0.91%***
	(0.17%)	(0.14%)	(0.27%)
Standard deviation	0.58%	0.44%	0.59%
	(0.09%)	(0.08%)	(0.16%)
β wrt US	-0.08*	0.45**	1.00
	(0.25)	(0.12)	
Correlation with US	-0.08**	0.61	1.00
	(0.26)	(0.16)	
Correlation with UK	0.37	1.00	0.61
	(0.23)		(0.16)

Table 6 – 5 Year Zero-Coupon Yield Variance Decompositions. Data is monthly. Subsample 1 is 2004M11-2010M8. Subsample 2 is 2010M9-2016M6. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Panel A: Nominal yield variance decomposition									
	France			UK			US		
	Whole sample	Subsample 1	Subsample 2	Whole sample	Subsample 1	Subsample 2	Whole sample	Subsample 1	Subsample 2
$\frac{Cov(\text{real yield,nominal yield})}{Var(\text{nominal yield})}$	73.56%	79.03%	60.53%	107.48%	112.45%	68.83%	77.40%	64.78%	112.57%
	(3.78%)	(7.75%)	(3.73%)	(4.05%)	(17.37%)	(6.44%)	(6.07%)	(10.28%)	(16.80%)
$\frac{Cov(\text{expected inflation,nominal yield})}{Var(\text{nominal yield})}$	1.43%	0.37%	6.80%***	-19.90%	-10.18%	-6.03%	4.22%	6.88%	-6.80%**
	(1.11%)	(0.80%)	(0.94%)	(4.04%)	(7.69%)	(12.49%)	(1.09%)	(1.64%)	(1.22%)
$\frac{Cov(\text{inflation risk premium,nominal yield})}{Var(\text{nominal yield})}$	25.01%	20.59%	32.67%	12.42%	-2.26%	37.20%**	18.38%	28.33%	-5.76%
	(2.83%)	(7.60%)	(3.13%)	(3.32%)	(11.23%)	(11.39%)	(5.39%)	(9.70%)	(16.94%)

Panel B: Inflation-linked yield variance decomposition									
	France			UK			US		
	Whole sample	Subsample 1	Subsample 2	Whole sample	Subsample 1	Subsample 2	Whole sample	Subsample 1	Subsample 2
$\frac{Cov(\text{real yield,inflation-linked yield})}{Var(\text{inflation-linked yield})}$	105.55%	97.64%	96.10%	109.22%	124.76%	77.02%	83.86%	80.69%	101.17%
	(6.09%)	(13.35%)	(8.94%)	(7.97%)	(22.29%)	(7.25%)	(10.27%)	(23.78%)	(6.96%)
$\frac{Cov(\text{liquidity premium,inflation-linked yield})}{Var(\text{inflation-linked yield})}$	-5.55%	2.36%	3.90%	-9.22%	-24.76%	22.98%	16.14%	19.31%	-1.17%
	(6.09%)	(13.35%)	(8.94%)	(7.97%)	(22.29%)	(7.25%)	(10.27%)	(23.78%)	(6.96%)

Table 7 – 5 Year Zero-Coupon Yield Correlation Decompositions. Data is monthly. Subsample 1 is 2004M11-2010M8. Subsample 2 is 2010M9-2016M6. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Panel A: Nominal yield correlation decomposition									
	France-UK			France-US			UK-US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Panel A1: Country 1 perspective									
$\frac{Cov(\text{real yield}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.69	0.64	0.47	0.61	0.46	0.21	1.04	1.02	0.68
	(0.05)	(0.11)	(0.08)	(0.07)	(0.18)	(0.12)	(0.05)	(0.20)	(0.06)
$\frac{Cov(\text{expected inflation}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.00	-0.01	0.00	-0.01	-0.02	-0.04	-0.21	-0.13	-0.29**
	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.02)	(0.04)	(0.06)	(0.08)
$\frac{Cov(\text{inflation risk premium}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.21	0.22	0.10	0.18	0.18	-0.10**	0.12	-0.02	0.41
	(0.03)	(0.08)	(0.09)	(0.03)	(0.07)	(0.06)	(0.04)	(0.12)	(0.11)
Panel A2: Country 2 perspective									
$\frac{Cov(\text{real yield}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.93	0.88	0.15*	0.55	0.39	-0.56**	0.72	0.53	0.54
	(0.05)	(0.24)	(0.13)	(0.10)	(0.21)	(0.33)	(0.08)	(0.13)	(0.35)
$\frac{Cov(\text{expected inflation}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	-0.14	-0.04	0.30**	0.03	0.03	-0.02	0.04	0.06	-0.08**
	(0.04)	(0.10)	(0.11)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
$\frac{Cov(\text{inflation risk premium}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.12	0.01	0.13	0.20	0.19	0.65	0.19	0.28	0.34
	(0.02)	(0.11)	(0.06)	(0.07)	(0.06)	(0.26)	(0.06)	(0.09)	(0.27)
Panel A3: Total correlation									
	0.91	0.86	0.57	0.79	0.61	0.07*	0.95	0.87	0.80
	(0.11)	(0.10)	(0.24)	(0.13)	(0.19)	(0.27)	(0.08)	(0.14)	(0.11)
Panel B: Inflation-linked yield correlation decompositions									
	France-UK			France-US			UK-US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Panel B1: Country 1 perspective									
$\frac{Cov(\text{real yield}_1,\text{inflation-linked yield}_2)}{SD(\text{inflation-linked yield}_1)SD(\text{inflation-linked yield}_2)}$	0.99	0.80	0.69	0.88	0.64	0.09*	1.01	0.91	0.63
	(0.06)	(0.16)	(0.09)	(0.09)	(0.25)	(0.29)	(0.10)	(0.30)	(0.14)
$\frac{Cov(\text{liquidity premium}_1,\text{inflation-linked yield}_2)}{SD(\text{inflation-linked yield}_1)SD(\text{inflation-linked yield}_2)}$	-0.09	-0.04	-0.12	-0.08	0.03	-0.10	-0.08	-0.10	-0.02
	(0.06)	(0.12)	(0.08)	(0.08)	(0.16)	(0.10)	(0.09)	(0.26)	(0.12)
Panel B2: Country 2 perspective									
$\frac{Cov(\text{real yield}_2\text{inflation-linked yield}_1)}{SD(\text{inflation-linked yield}_1)SD(\text{inflation-linked yield}_2)}$	0.94	0.79	0.26	0.62	0.45	-0.22*	0.77	0.70	0.49
	(0.08)	(0.30)	(0.18)	(0.12)	(0.29)	(0.31)	(0.10)	(0.21)	(0.15)
$\frac{Cov(\text{liquidity premium}_2\text{inflation-linked yield}_1)}{SD(\text{inflation-linked yield}_1)SD(\text{inflation-linked yield}_2)}$	-0.04	-0.04	0.31	0.19	0.23	0.21	0.16	0.11	0.12
	(0.08)	(0.23)	(0.12)	(0.09)	(0.21)	(0.06)	(0.09)	(0.20)	(0.03)
Panel B3: Total correlation									
	0.90	0.75	0.57	0.81	0.67	-0.01**	0.93	0.81	0.61
	(0.10)	(0.08)	(0.12)	(0.11)	(0.14)	(0.26)	(0.05)	(0.16)	(0.20)

Table 8 – 5 Year Zero-Coupon Real Yield Regressions on Economic Factors. Data is quarterly. Regressions are OLS regressions including constants. The sample is 2004Q4-2016Q2. Standard errors in parentheses are Newey-West standard errors computed with 8 lags. *, **, and *** indicate the statistical significance at the 10%, 5%, and 1% significance level, respectively.

	France					
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Expected consumption growth	2.31**					-0.24
	(0.39)					(0.73)
Consumption growth variance		-0.51				0.34
		(1.13)				(0.31)
Macroeconomic risk aversion			-0.97***			-1.08***
			(0.07)			(0.24)
Financial risk aversion				16.03		-35.29
				(86.43)		(30.03)
Discretionary monetary policy					0.49	-0.08
					(0.48)	(0.19)
Adjusted R^2	70.01%	-1.53%	86.32%	-2.15%	3.01%	85.40%
	UK					
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Expected consumption growth	-0.93					0.66
	(0.90)					(0.48)
Consumption growth variance		-1.65				0.25
		(1.87)				(0.36)
Macroeconomic risk aversion			-1.54***			-1.41***
			(0.13)			(0.14)
Financial risk aversion				96.39		131.32***
				(157.82)		(40.35)
Discretionary monetary policy					0.96***	0.35**
					(0.24)	(0.13)
Adjusted R^2	0.52%	0.83%	84.54%	-1.48%	37.84%	89.26%
	US					
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Expected consumption growth	2.40*					-0.96
	(1.33)					(0.62)
Consumption growth variance		-2.89				-2.54
		(4.72)				(1.85)
Macroeconomic risk aversion			-0.92***			-0.76***
			(0.12)			(0.13)
Financial risk aversion				-71.82		-102.57
				(127.56)		(72.33)
Discretionary monetary policy					0.60***	0.35**
					(0.22)	(0.16)
Adjusted R^2	21.37%	-0.39%	73.50%	-0.99%	40.94%	77.79%

Table 9 – Model 5 Year Real Yield Correlations. Subsample 1 is 2004Q4-2010Q2. Subsample 2 is 2010Q3-2016Q2. In Model 1, the only factor determining real yields is macroeconomic risk aversion. In Model 2, the only factor determining real yields is discretionary monetary policy shocks. In Model 3, both macroeconomic risk aversion and monetary policy shocks are real yield determinants. GMM-based data standard errors are in parentheses.

Panel A: France-UK			
	Full sample	Subsample 1	Subsample 2
Data	0.86	0.68	0.37
	(0.12)	(0.16)	(0.23)
Model 1	0.88	0.70	-0.31
Model 2	0.09	0.05	-0.30
Model 3	0.93	0.68	0.64
Panel B: France-US			
	Full sample	Subsample 1	Subsample 2
Data	0.75	0.58	-0.08
	(0.10)	(0.20)	(0.26)
Model 1	0.88	0.82	-0.19
Model 2	0.22	0.36	-0.33
Model 3	0.91	0.72	0.49
Panel C: UK-US			
	Full sample	Subsample 1	Subsample 2
Data	0.90	0.78	0.61
	(0.06)	(0.18)	(0.16)
Model 1	0.97	0.95	0.82
Model 2	0.81	0.53	0.77
Model 3	0.97	0.94	0.73

Table 10 – Model Variance Decompositions of Inflation-linked Yields. Entries are $\frac{Cov(\text{real yield,inflation-linked yield})}{Var(\text{inflation-linked yield})}$. Subsample 1 is 2004Q4-2010Q2. In Model 1, the only factor determining real yields is macroeconomic risk aversion. In Model 2, the only factor determining real yields is discretionary monetary policy shocks. In Model 3, both macroeconomic risk aversion and monetary policy shocks are real yield determinants. GMM-based data standard errors are in parentheses.

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	105.55%	97.64%	96.10%	109.22%	124.76%	77.02%	83.86%	80.69%	101.17%
	(6.09%)	(13.35%)	(8.94%)	(7.97%)	(22.29%)	(7.25%)	(10.27%)	(23.78%)	(6.96%)
Model 1	101.30%	92.32%	49.09%	109.78%	122.83%	61.82%	80.42%	90.38%	76.52%
Model 2	33.71%	15.55%	41.37%	84.99%	48.08%	83.27%	68.04%	58.79%	74.31%
Model 3	101.17%	91.92%	51.08%	107.66%	122.08%	41.44%	79.66%	85.00%	57.35%

Table 11 – 5 Year Zero-Coupon Inflation Risk Premium Regressions on Economic Factors. Data is quarterly. Regressions are OLS regressions including constants. The sample is 2004Q4-2016Q2. Standard errors in parentheses are Newey and West (1987) standard errors computed with 8 lags. *, **, and *** indicate the statistical significance at the 10%, 5%, and 1% significance level, respectively.

	France						
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6	Spec 7
Expected inflation-consumption growth covariance	-1.04						2.96
	(2.92)						(1.92)
Consumption growth variance		0.27					1.02***
		(0.35)					(0.33)
Expected inflation variance			-18.03				-7.91
			(28.75)				(11.03)
Macroeconomic risk aversion				-2.31***			-2.84***
				(0.39)			(0.28)
Financial risk aversion					-17.67		-80.44***
					(27.81)		(20.03)
Discretionary monetary policy						0.10	-0.19**
						(0.19)	(0.09)
Adjusted R^2	-0.87%	-0.22%	-0.55%	55.53%	-0.76%	-1.07%	68.37%
	UK						
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6	Spec 7
Expected inflation-consumption growth covariance	0.21						-0.21
	(0.38)						(0.53)
Consumption growth variance		0.43**					0.69
		(0.21)					(0.62)
Expected inflation variance			0.19				0.93
			(0.21)				(0.64)
Macroeconomic risk aversion				-0.53*			-1.03*
				(0.30)			(0.62)
Financial risk aversion					-113.80**		-184.35**
					(52.82)		(71.33)
Discretionary monetary policy						0.08*	-0.03
						(0.05)	(0.11)
Adjusted R^2	-0.79%	0.24%	-0.61%	5.85%	9.88%	1.01%	33.38%
	US						
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6	Spec 7
Expected inflation-consumption growth covariance	-0.17						-2.44
	(1.74)						(1.97)
Consumption growth variance		-0.16					0.55
		(1.76)					(1.66)
Expected inflation variance			2.83				0.65
			(1.79)				(4.28)
Macroeconomic risk aversion				-1.60***			0.01
				(0.42)			(0.83)
Financial risk aversion					-105.58**		-196.52***
					(43.60)		(45.67)
Discretionary monetary policy						0.15	0.21*
						(0.09)	(0.11)
Adjusted R^2	-1.20%	-0.22%	4.88%	17.66%	10.51%	9.33%	33.27%

Table 12 – Model-implied 5 Year Nominal Yield Correlations. The real yield model is a one-factor where the only factor is macroeconomic risk aversion. The inflation risk premium model is a three-factor model, where the factors are macroeconomic risk aversion, financial risk aversion and discretionary monetary policy. GMM-based standard errors using 12 Newey-West lags are in parentheses.

Panel A: France-UK			
	Full sample	Subsample 1	Subsample 2
Data	0.91	0.86	0.57
	(0.11)	(0.10)	(0.24)
Model	0.86	0.71	0.00
Panel B: France-US			
	Full sample	Subsample 1	Subsample 2
Data	0.79	0.61	0.07
	(0.13)	(0.19)	(0.27)
Model	0.84	0.75	-0.11
Panel C: UK-US			
	Full sample	Subsample 1	Subsample 2
Data	0.95	0.87	0.80
	(0.08)	(0.14)	(0.11)
Model	0.97	0.96	0.48

Table 13 – Model-implied 5 Year Nominal Yield Variance Decompositions. The real yield model is a one-factor where the only factor is macroeconomic risk aversion. The inflation risk premium model is a three-factor model, where the factors are macroeconomic risk aversion, financial risk aversion and discretionary monetary policy. GMM-based data standard errors, using 12 Newey-West lags, are in parentheses.

$$\frac{Cov(\text{real yield,nominal yield})}{Var(\text{nominal yield})}$$

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	73.56%	79.03%	60.53%	107.48%	112.45%	68.83%	77.40%	64.78%	112.57%
	(3.78%)	(7.75%)	(3.73%)	(4.05%)	(17.37%)	(6.44%)	(6.07%)	(10.28%)	(16.80%)
Model	73.04%	71.15%	59.07%	110.61%	93.31%	134.78%	74.63%	67.56%	103.12%

$$\frac{Cov(\text{expected inflation,nominal yield})}{Var(\text{nominal yield})}$$

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	1.43%	0.37%	6.80%	-19.90%	-10.18%	-6.03%	4.22%	6.88%	-6.80%
	(1.11%)	(0.80%)	(0.94%)	(4.04%)	(7.69%)	(12.49%)	(1.09%)	(1.64%)	(1.22%)
Model	0.87%	0.75%	11.75%	-22.66%	-10.79%	-32.34%	5.18%	6.17%	2.63%

$$\frac{Cov(\text{inflation risk premium,nominal yield})}{Var(\text{nominal yield})}$$

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	25.01%	20.59%	32.67%	12.42%	-2.26%	37.20%	18.38%	28.33%	-5.76%
	(2.83%)	(7.60%)	(3.13%)	(3.32%)	(11.23%)	(11.39%)	(5.39%)	(9.70%)	(16.94%)
Model	26.09%	28.10%	29.18%	12.06%	17.48%	-2.44%	20.19%	26.27%	-5.76%

Table 14 – Annualized 5 Year - 1 Quarter Zero-Coupon Yield Curve Slopes. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Nominal slope			Real slope		
	France	UK	US	France	UK	US
Average	0.94%	0.66%	1.12%	0.43%	-0.79%	0.68%
	(0.19%)	(0.27%)	(0.23%)	(0.15%)	(0.22%)	(0.24%)
Standard deviation	0.64%	0.93%	0.78%	0.58%	0.85%	0.83%
	(0.11%)	(0.13%)	(0.13%)	(0.10%)	(0.09%)	(0.11%)
Cov(real slope, nominal slope)/Var(nominal slope)	77.92%	78.56%	94.13%			
	(9.05%)	(8.36%)	(7.54%)			
Correlation with US	0.49	0.76	1.00	0.25	0.48	1.00
	(0.17)	(0.13)		(0.17)	(0.14)	
Correlation with UK	0.74	1.00	0.76	0.75	1.00	0.48
	(0.11)		(0.13)	(0.08)		(0.14)
Subsample 1: 2004M11-2010M8						
	Nominal slope			Real slope		
	France	UK	US	France	UK	US
Average	0.95%	0.42%	0.97%	0.34%	-1.04%	0.44%
	(0.31%)	(0.52%)	(0.47%)	(0.25%)	(0.38%)	(0.43%)
Standard deviation	0.71%	1.16%	0.99%	0.65%	0.98%	0.97%
	(0.17%)	(0.20%)	(0.15%)	(0.15%)	(0.12%)	(0.09%)
Cov(real slope, nominal slope)/Var(nominal slope)	78.36%	72.21%	90.70%			
	(11.14%)	(10.56%)	(8.02%)			
Correlation with US	0.71	0.74	1.00	0.55	0.62	1.00
	(0.18)	(0.19)		(0.15)	(0.16)	
Correlation with UK	0.93	1.00	0.74	0.86	1.00	0.62
	(0.05)		(0.19)	(0.06)		(0.16)
Subsample 2: 2010M9-2016M6						
	Nominal slope			Real slope		
	France	UK	US	France	UK	US
Average	0.93%	0.91%	1.27%	0.52%	-0.54%	0.93%
	(0.22%)	(0.15%)	(0.15%)	(0.19%)	(0.19%)	(0.26%)
Standard deviation	0.56%	0.51%***	0.42%***	0.50%	0.60%*	0.57%**
	(0.13%)	(0.07%)	(0.13%)	(0.12%)	(0.10%)	(0.15%)
Cov(real slope, nominal slope)/Var(nominal slope)	77.80%	100.71%	95.62%			
	(7.31%)	(13.74%)	(20.54%)			
Correlation with US	-0.02**	0.81	1.00	-0.51***	-0.09**	1.00
	(0.28)	(0.11)		(0.22)	(0.26)	
Correlation with UK	0.42*	1.00	0.81	0.50*	1.00	-0.09**
	(0.25)		(0.11)	(0.19)		(0.26)

Table 15 – 5 Year Zero-Coupon Yield Correlation Decompositions: Further International Evidence. Data is monthly 2011:M4-2016:M6. For Australia, Germany, and Sweden inflation-linked yields are decomposed into real yields and the liquidity premia in the same way as for France, the UK, and the US, except that breakeven inflation regressions are run separately for each country, because liquidity proxies vary by country. Liquidity proxies for Australia and Germany are trading volume ratios in inflation-linked versus nominal bonds, inflation swap spreads, and off-the-run premia. Liquidity proxies for Sweden are trading volume ratios in inflation-linked versus nominal bonds and off-the-run premia. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses.

Panel A: Nominal variance decompositions			
	Australia (AU)	Germany (GER)	Sweden (SWE)
$\frac{Cov(\text{real yield,nominal yield})}{Var(\text{nominal yield})}$	71.27%	61.35%	75.80%
	(5.59%)	(2.37%)	(7.03%)
$\frac{Cov(\text{expected inflation,nominal yield})}{Var(\text{nominal yield})}$	-3.00%	8.36%	2.63%
	(1.81%)	(1.58%)	(1.24%)
$\frac{Cov(\text{inflation risk premium,nominal yield})}{Var(\text{nominal yield})}$	31.73%	30.29%	21.57%
	(4.23%)	(1.39%)	(6.78%)
Nominal yield standard deviation	0.77%	0.65%	0.79%
	(0.09%)	(0.08%)	(0.11%)

Panel B: Nominal correlation decompositions						
	AU-FR	AU-GER	AU-UK	AU-US	AU-SWE	FR-GER
Country 1 perspective:						
$\frac{Cov(\text{real yield}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.58	0.64	0.51	0.17	0.64	0.55
	(0.07)	(0.05)	(0.08)	(0.17)	(0.06)	(0.03)
$\frac{Cov(\text{expected inflation}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	-0.01	-0.02	-0.03	-0.02	-0.02	0.07
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
$\frac{Cov(\text{inflation risk premium}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.33	0.33	0.16	-0.05	0.30	0.33
	(0.04)	(0.04)	(0.08)	(0.03)	(0.06)	(0.03)
Country 2 perspective:						
$\frac{Cov(\text{real yield}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.53	0.56	0.21	-0.59	0.69	0.57
	(0.04)	(0.02)	(0.14)	(0.43)	(0.08)	(0.02)
$\frac{Cov(\text{expected inflation}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.06	0.08	0.35	0.01	0.02	0.10
	(0.01)	(0.02)	(0.15)	(0.02)	(0.01)	(0.02)
$\frac{Cov(\text{inflation risk premium}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.31	0.31	0.08	0.68	0.21	0.29
	(0.05)	(0.01)	(0.09)	(0.28)	(0.06)	(0.02)
Total correlation	0.90	0.95	0.64	0.10	0.92	0.96
	(0.07)	(0.04)	(0.09)	(0.18)	(0.06)	(0.04)
	FR-SWE	GER-UK	GER-US	GER-SWE	UK-SWE	US-SWE
Country 1 perspective:						
$\frac{Cov(\text{real yield}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.51	0.38	0.08	0.51	0.08	-0.85
	(0.03)	(0.08)	(0.11)	(0.04)	(0.18)	(0.38)
$\frac{Cov(\text{expected inflation}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.08	-0.01	-0.07	0.10	0.43	0.02
	(0.01)	(0.03)	(0.03)	(0.02)	(0.14)	(0.02)
$\frac{Cov(\text{inflation risk premium}_1,\text{nominal yield}_2)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.32	0.18	-0.01	0.31	-0.02	0.77
	(0.06)	(0.05)	(0.06)	(0.08)	(0.09)	(0.26)
Country 2 perspective:						
$\frac{Cov(\text{real yield}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.70	0.14	-0.69	0.69	0.37	-0.08
	(0.08)	(0.14)	(0.35)	(0.08)	(0.15)	(0.15)
$\frac{Cov(\text{expected inflation}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.04	0.38	0.03	0.02	-0.01	-0.03
	(0.02)	(0.12)	(0.01)	(0.01)	(0.01)	(0.01)
$\frac{Cov(\text{inflation risk premium}_2,\text{nominal yield}_1)}{SD(\text{nominal yield}_1)SD(\text{nominal yield}_2)}$	0.17	0.03	0.66	0.21	0.13	0.05
	(0.06)	(0.08)	(0.26)	(0.06)	(0.06)	(0.07)
Total correlation	0.91	0.55	0.00	0.92	0.49	-0.07
	(0.07)	(0.16)	(0.16)	(0.07)	(0.16)	(0.17)

Appendix I: Historical Background on Inflation-Linked Debt in the US, UK and France

Here we offer some background on the experiences of three developed markets with inflation-protected bonds, the UK, France and the euro area, and finally, the US (which has become the largest index-linked market with over $1300 billon outstanding at the end of 2017).

The UK. The UK program is the oldest program, with the UK government issuing inflation-indexed Gilts since March 1981. Importantly, the index-linked market is an important part of the total gilt market, representing over 30% of the total market at the end of 2017, making it the largest index-linked program in relative terms. Changes in UK financial regulation did prove critical in further boosting demand for indexed gilts. The Pension Act of 2004 requires pension funds to prove that they can meet their future liabilities, which has led to a strong demand for long-dated indexed gilts.

The euro area and France. France first introduced indexed Treasury bonds (the so-called OATis) in 1998. An issue of special interest in the euro area is to what inflation index these bonds should be indexed. France first used its local CPI, excluding tobacco. Later on, it started to issue bonds indexed to the HPIC (the Harmonized Index of Consumer Prices), again excluding tobacco, which is an euro-wide price index, regularly published by Eurostat. This index has now become the market benchmark in the euro area, with other countries issuing inflation-linked bonds indexed to that index (Italy, Greece and Germany) and financial products (swaps, futures) linked to it as well. The euro area government linked bond market has now overtaken the UK market to become the second largest linker market in the world behind the US, both in terms of outstanding amounts and turnover (see Garcia and van Rixtel, 2007, for some relevant data).

The US. The US started issuing TIPS in January 1997. While the TIPS program in the US initially met with some enthusiasm (see Sack and Elsasser, 2004), the program grew rather slowly. The outstanding amount of TIPS, which grew from around \$150 billion at the end of the nineties to close to \$1300 billion at the end of 2017, representing only around 10% of the total medium- and long-term government debt outstanding. The Treasury affirmed its commitment to the program in 2002. It is often argued that during its infancy, up to around 2004, the TIPS market was very illiquid and even somewhat "unknown, inefficiently priced" (e.g., Sack and Elsasser, 2004, and Gürkaynak, Sack, and Wright, 2010).

Appendix II: GMM Standard Errors

Suppose that $\{y^n_{t,1}\}_{t=1:T}$ is the time series of yields in country 1 and $\{y^n_{t,2}\}_{t=1:T}$ is the time series of yields in country 2. The GMM orthogonality conditions we use to obtain standard errors are:

$$[\frac{1}{T}\sum_{t=1}^{T} y^n_{t,1}] - \mu_1 = 0,$$

$$[\frac{1}{T}\sum_{t=1}^{T} y^n_{t,2}] - \mu_2 = 0,$$

$$[\frac{1}{T}\sum_{t=1}^{T} (y^n_{t,1} - \mu_1)^2] - \sigma_1^2 = 0,$$

$$[\frac{1}{T}\sum_{t=1}^{T} (y^n_{t,2} - \mu_2)^2] - \sigma_2^2 = 0,$$

$$[\frac{1}{T}\sum_{t=1}^{T} (y^n_{t,1} - \mu_1)(y^n_{t,2} - \mu_2)] - \sigma_{12} = 0,$$

where μ_1 and μ_2 are averages, σ_1 and σ_2 standard deviations, and σ_{12} the covariance of the two series. The weighting matrix is, as usual, the inverse of an estimate of the spectral density at frequency zero of the orthogonality conditions, computed as in Newey and West (1987) with 12 lags. The variance covariance matrix is then the usual optimal GMM estimator. We obtain standard errors for correlations and betas from standard errors for standard deviations and covariances using the delta method. Standard errors for variance and correlation decompositions are also obtained by applying the delta method to variance and covariance standard errors obtained via GMM.

In order to compute the statistical significance of the changes in parameters across the two subsamples, we use a system similar to the system above, but estimate the difference between the parameters across the subsamples as a separate parameter. For instance, the conditions for averages become:

$$[\frac{1}{T_1}\sum_{t=1}^{T_1} y_{t,1}^n] - \mu_{11} = 0,$$

$$[\frac{1}{T-T_1}\sum_{t=T_1+1}^{T} y_{t,1}^n] - (\mu_{11} + \mu_{1\to 2}) = 0,$$

where T_1 is the number of data points in the first subsample. The statistical significance of $\mu_{1\to 2}$ then determines the statistical significance of the parameter change across two subsamples. The conditions for other parameters follow the same approach.

Appendix III: One Year Inflation Survey Forecasts

One Year Ahead Survey Expected Inflation. Data is quarterly. GMM standard errors computed using 4 Newey-West (1987) lags are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6			
	France	UK	US
Average	1.50%	2.04%	2.02%
	(0.08%)	(0.10%)	(0.11%)
Standard deviation	0.27%	0.41%	0.34%
	(0.14%)	(0.07%)	(0.11%)
β wrt US	0.27	0.28	1.00
	(0.11)	(0.31)	
Correlation with US	0.34	0.23	1.00
	(0.14)	(0.26)	
Correlation with UK	0.41	1.00	0.23
	(0.18)		(0.26)
Subsample 1: 2004M11-2010M8			
	France	UK	US
Average	1.60%	1.92%	2.10%
	(0.08%)	(0.08%)	(0.16%)
Standard deviation	0.22%	0.38%	0.45%
	(0.14%)	(0.12%)	(0.15%)
β wrt US	0.24	0.56	1.00
	(0.08)	(0.17)	
Correlation with US	0.50	0.66	1.00
	(0.17)	(0.20)	
Correlation with UK	0.34	1.00	0.66
	(0.15)		(0.20)
Subsample 2: 2010M9-2016M6			
	France	UK	US
Average	1.41%	2.16%	1.94%
	(0.13%)	(0.17%)	(0.03%)
Standard deviation	0.29%	0.42%	0.16%**
	(0.14%)	(0.16%)	(0.12%)
β wrt US	-0.07	-0.92***	1.00
	(0.28)	(0.32)	
Correlation with US	-0.04*	-0.35***	1.00
	(0.15)	(0.12)	
Correlation with UK	0.75**	1.00	-0.35***
	(0.10)		(0.12)

Appendix IV: Main Results under Alternative Liquidity Premia Specifications

IV.A: Liquidity Premium Estimated Using Only Inflation Swap Spread as a Liquidity Proxy

Annualized 5 Year Zero-Coupon Liquidity and Inflation Risk Premia. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.44%	0.80%	0.54%	0.13%	0.44%	0.08%
	(0.05%)	(0.10%)	(0.11%)	(0.13%)	(0.09%)	(0.11%)
Standard deviation	0.26%	0.41%	0.40%	0.48%	0.42%	0.48%
	(0.08%)	(0.09%)	(0.10%)	(0.12%)	(0.07%)	(0.09%)
β wrt US	0.29	0.40	1.00	0.75	0.47	1.00
	(0.05)	(0.11)		(0.16)	(0.14)	
Correlation with US	0.45	0.39	1.00	0.75	0.53	1.00
	(0.08)	(0.11)		(0.16)	(0.16)	
Correlation with UK	0.52	1.00	0.39	0.47	1.00	0.53
	(0.12)		(0.11)	(0.14)		(0.16)

Subsample 1: 2004M11-2010M8						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.42%	0.71%	0.75%	0.45%	0.64%	0.27%
	(0.10%)	(0.20%)	(0.16%)	(0.08%)	(0.08%)	(0.17%)
Standard deviation	0.26%	0.52%	0.46%	0.30%	0.43%	0.53%
	(0.12%)	(0.12%)	(0.13%)	(0.11%)	(0.10%)	(0.12%)
β wrt US	0.43	0.71	1.00	0.43	0.50	1.00
	(0.03)	(0.11)		(0.08%)	(0.22%)	
Correlation with US	0.75	0.63	1.00	0.77	0.62	1.00
	(0.05)	(0.10)		(0.14)	(0.27)	
Correlation with UK	0.71	1.00	0.63	0.61	1.00	0.62
	(0.12)		(0.10)	(0.10)		(0.27)

Subsample 2: 2010M9-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.47%	0.88%	0.33***	-0.19%***	0.23%***	-0.11%*
	(0.08%)	(0.10%)	(0.05%)	(0.16%)	(0.09%)	(0.12%)
Standard deviation	0.25%	0.24***	0.14%	0.41%	0.30%	0.33%
	(0.12%)	(0.08%)	(0.07%)	(0.14%)	(0.13%)	(0.15%)
β wrt US	0.61	0.88	1.00	0.96***	-0.03*	1.00
	(0.29)	(0.18)		(0.11)	(0.21)	
Correlation with US	0.33**	0.49	1.00	0.76	-0.03*	1.00
	(0.16)	(0.10)		(0.08)	(0.22)	
Correlation with UK	0.14**	1.00	0.49	-0.16***	1	-0.03*
	(0.20)		(0.10)	(0.24)		(0.22)

Annualized 5 Year Zero-Coupon Real Yields. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6			
	France	UK	US
Average	0.08%	-0.65%	0.00%
	(0.31%)	(0.49%)	(0.32%)
Standard deviation	0.98%	1.64%	1.05%
	(0.13%)	(0.13%)	(0.14%)
β wrt US	0.72	1.39	1.00
	(0.09)	(0.09)	
Correlation with US	0.77	0.89	1.00
	(0.09)	(0.06)	
Correlation with UK	0.89	1.00	0.89
	(0.11)		(0.05)
Subsample 1: 2004M11-2010M8			
	France	UK	US
Average	0.88%	0.75%	0.82%
	(0.26%)	(0.47%)	(0.30%)
Standard deviation	0.63%	1.10%	0.73%
	(0.14%)	(0.18%)	(0.09%)
β wrt US	0.48	1.12	1.00
	(0.20)	(0.31)	
Correlation with US	0.56	0.74	1.00
	(0.23)	(0.21)	
Correlation with UK	0.73	1.00	0.74
	(0.15)		(0.21)
Subsample 2: 2010M9-2016M6			
	France	UK	US
Average	-0.72%***	-2.06%***	-0.82%***
	(0.14%)	(0.13%)	(0.25%)
Standard deviation	0.52%	0.43%	0.56%
	(0.09%)	(0.08%)	(0.16%)
β wrt US	0.04	0.46**	1.00
	(0.24)	(0.13)	
Correlation with US	0.04*	0.60	1.00
	(0.26)	(0.17)	
Correlation with UK	0.50	1.00	0.60
	(0.22)		(0.17)

IV.B: Liquidity Premiums Estimated for Each Country Separately Using Only Inflation Swap Spread as a Proxy

Annualized 5 Year Zero-Coupon Liquidity and Inflation Risk Premia. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.43%	0.94%	0.61%	0.12%	0.59%	0.15%
	(0.05%)	(0.12%)	(0.12%)	(0.13%)	(0.09%)	(0.11%)
Standard deviation	0.25%	0.49%	0.45%	0.48%	0.42%	0.48%
	(0.08%)	(0.09%)	(0.10%)	(0.12%)	(0.08%)	(0.10%)
β wrt US	0.25	0.42	1.00	0.80	0.38	1.00
	(0.04)	(0.12)		(0.13)	(0.14)	
Correlation with US	0.45	0.39	1.00	0.79	0.44	1.00
	(0.08)	(0.11)		(0.13)	(0.16)	
Correlation with UK	0.52	1.00	0.39	0.43	1.00	0.44
	(0.12)		(0.11)	(0.13)		(0.16)
Subsample 1: 2004M11-2010M8						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.40%	0.84%	0.85%	0.44%	0.77%	0.37%
	(0.10%)	(0.23%)	(0.19%)	(0.08%)	(0.08%)	(0.16%)
Standard deviation	0.25%	0.61%	0.52%	0.30%	0.43%	0.50%
	(0.12%)	(0.12%)	(0.13%)	(0.11%)	(0.10%)	(0.12%)
β wrt US	0.37	0.74	1.00	0.48	0.38	1.00
	(0.03)	(0.11)		(0.08)	(0.26)	
Correlation with US	0.75	0.63	1.00	0.79	0.45	1.00
	(0.05)	(0.10)		(0.14)	(0.30)	
Correlation with UK	0.71	1.00	0.63	0.50	1.00	0.45
	(0.12)		(0.10)	(0.18)		(0.30)
Subsample 2: 2010M9-2016M6						
	Liquidity premium			Inflation risk premium		
	France	UK	US	France	UK	US
Average	0.45%	1.05%	0.37%***	-0.20%***	0.40%***	-0.07%**
	(0.06%)	(0.10%)	(0.04%)	(0.16%)	(0.09%)	(0.13%)
Standard deviation	0.24%	0.28%***	0.15%	0.41%	0.31%	0.33%
	(0.12%)	(0.08%)	(0.07%)	(0.14%)	(0.12%)	(0.16%)
β wrt US	0.55	0.86	1.00	0.96***	-0.04	1.00
	(0.25)	(0.19)		(0.10)	(0.22)	
Correlation with US	0.35**	0.47	1.00	0.78	-0.04	1.00
	(0.16)	(0.10)		(0.08)	(0.23)	
Correlation with UK	0.17***	1.00	0.47	-0.09*	1.00	-0.04
	(0.20)		(0.10)	(0.26)		(0.23)

Annualized 5 Year Zero-Coupon Real Yields. Data is monthly. GMM standard errors, computed using 12 Newey-West (1987) lags, are in parentheses. For subsample 2 *, **, and *** indicate if statistics are different from subsample 1 at the 10%, 5%, and 1% significance level, respectively.

Whole sample: 2004M11-2016M6			
	France	UK	US
Average	0.10%	-0.80%	-0.07%
	(0.31%)	(0.50%)	(0.31%)
Standard deviation	0.98%	1.68%	1.03%
	(0.13%)	(0.13%)	(0.14%)
β wrt US	0.71	1.43	1.00
	(0.09)	(0.09)	
Correlation with US	0.75	0.88	1.00
	(0.09)	(0.05)	
Correlation with UK	0.88	1.00	0.88
	(0.12)		(0.05)
Subsample 1: 2004M11-2010M8			
	France	UK	US
Average	0.89%	0.62%	0.72%
	(0.26%)	(0.50%)	(0.32%)
Standard deviation	0.63%	1.17%	0.75%
	(0.14%)	(0.18%)	(0.08%)
β wrt US	0.44	1.15	1.00
	(0.20)	(0.33)	
Correlation with US	0.53	0.73	1.00
	(0.23)	(0.21)	
Correlation with UK	0.71	1.00	0.73
	(0.15)		(0.21)
Subsample 2: 2010M9-2016M6			
	France	UK	US
Average	-0.70%***	-2.22%***	-0.86%***
	(0.15%)	(0.14%)	(0.25%)
Standard deviation	0.52%	0.44%	0.56%
	(0.09%)	(0.08%)	(0.16%)
β wrt US	0.02	0.46**	1.00
	(0.24)	(0.13)	
Correlation with US	0.03	0.59	1.00
	(0.26)	(0.16)	
Correlation with UK	0.45	1.00	0.59
	(0.22)		(0.16)

Appendix V: Model solutions

The price of zero-coupon n period real bond at time t is:

$$P_{t,n} = e^{R_{0,n}+R^g_{1,n}g_t+R^q_{1,n}q_t+R^v_{1,n}v_t},$$

$$R_{0,1} = \ln\beta + \gamma\mu_q(1-\phi_{qq}),$$

$$R^g_{1,1} = -\gamma,$$

$$R^q_{1,1} = -\gamma(1-\phi_{qq}) + \frac{1}{2}\gamma^2\sigma^2_{qq},$$

$$R^v_{1,1} = \frac{1}{2}\gamma^2(\sigma_{cc}-\sigma_{qc})^2,$$

$$R_{0,n+1} = R_{0,n} + R_{0,1} + R^g_{1,n}\mu_g(1-\phi_{gg}) + R^q_{1,n}\mu_q(1-\phi_{qq}) + R^v_{1,n}\mu_v(1-\phi_{vv}) + \frac{1}{2}(R^g_{1,n})^2\sigma^2_{gg},$$

$$R^g_{1,n+1} = R^g_{1,n}\phi_{gg} - \gamma,$$

$$R^q_{1,n+1} = R^q_{1,n}\phi_{qq} - \gamma(1-\phi_{qq}) + \frac{1}{2}\sigma^2_{qq}(R^q_{1,n}+\gamma)^2,$$

$$R^v_{1,n+1} = R^v_{1,n}\phi_{vv} + \frac{1}{2}(R^g_{1,n}\sigma_{gc} + R^q_{1,n}\sigma_{qc} + R^v_{1,n}\sigma_{vc} + \gamma(\sigma_{qc}-\sigma_{cc}))^2 + \frac{1}{2}(R^v_{1,n})^2\sigma^2_{vv}.$$

Log per period yields can then be obtained as:

$$r_{t,n} = r_{0,n} + r'_{1,n}X_t,$$

$$r_{0,n} = -\frac{1}{n}R_{0,n},$$

$$r_{1,n} = \begin{bmatrix} -\frac{1}{n}R^g_{1,n} \\ -\frac{1}{n}R^q_{1,n} \\ -\frac{1}{n}R^v_{1,n} \end{bmatrix},$$

$$X_t = \begin{bmatrix} g_t \\ q_t \\ v_t \end{bmatrix}.$$

The price of zero-coupon n period nominal bond at time t is:

$$P^{\$}_{t,n} = e^{R^{\$}_{0,n} + R^{g\$}_{1,n} g_t + R^{q\$}_{1,n} q_t + R^{v\$}_{1,n} v_t + R^{p}_{1,n} p_t + R^{\omega}_{1,n} \omega_t},$$

$$R^{\$}_{0,1} = R_{0,1},$$

$$R^{g\$}_{1,1} = R^{g}_{1,1},$$

$$R^{q\$}_{1,1} = R^{q}_{1,1},$$

$$R^{v\$}_{1,1} = R^{v}_{1,1}$$

$$R^{p}_{1,1} = -1,$$

$$R^{\omega}_{1,1} = \frac{1}{2}\sigma^2_{\pi\pi},$$

$$R^{\$}_{0,n+1} = R^{\$}_{0,n} + R^{\$}_{0,1} + R^{g\$}_{1,n}\mu_g(1-\phi_{gg}) + R^{q\$}_{1,n}\mu_q(1-\phi_{qq}) + R^{v\$}_{1,n}\mu_v(1-\phi_{vv}) + R^{p}_{1,n}\mu_p(1-\phi_{pp}) +$$
$$R^{\omega}_{1,n}\mu_\omega(1-\phi_{\omega\omega}) + \frac{1}{2}(R^{g\$}_{1,n})^2\sigma^2_{gg},$$

$$R^{g\$}_{1,n+1} = R^{g\$}_{1,n}\phi_{gg} - \gamma,$$

$$R^{q\$}_{1,n+1} = R^{q\$}_{1,n}\phi_{qq} - \gamma(1-\phi_{qq}) + \frac{1}{2}(R^{q\$}_{1,n}\sigma_{qq} + \gamma\sigma_{qq} + R^{p}_{1,n}\sigma_{pq})^2,$$

$$R^{v\$}_{1,n+1} = R^{v\$}_{1,n}\phi_{vv} + \frac{1}{2}(R^{g\$}_{1,n}\sigma_{gc} + R^{q\$}_{1,n}\sigma_{qc} + R^{v\$}_{1,n}\sigma_{vc} + R^{p}_{1,n}\sigma_{pc} + \gamma(\sigma_{qc} - \sigma_{cc}))^2 + \frac{1}{2}(R^{v\$}_{1,n}\sigma_{vv} + R^{\omega}_{1,n}\sigma_{\omega v})^2,$$

$$R^{p}_{1,n+1} = R^{p}_{1,n}\phi_{pp} - 1,$$

$$R^{\omega}_{1,n+1} = R^{\omega}_{1,n}\phi_{\omega\omega} + \frac{1}{2}(R^{p}_{1,n}\sigma_{p\pi} + R^{\omega}_{1,n}\sigma_{\omega\pi} - \sigma_{\pi\pi})^2.$$

Log per period yields can then be obtained as:

$$
\begin{aligned}
r_{t,n}^{\$} &= r_{0,n}^{\$} + (r_{1,n}^{\$})' X_t^{\$}, \\
r_{0,n}^{\$} &= -\frac{1}{n} R_{0,n}^{\$}, \\
r_{1,n}^{\$} &= \begin{bmatrix} -\frac{1}{n} R_{1,n}^{g\$} \\ -\frac{1}{n} R_{1,n}^{q\$} \\ -\frac{1}{n} R_{1,n}^{v\$} \\ -\frac{1}{n} R_{1,n}^{p} \\ -\frac{1}{n} R_{1,n}^{\omega} \end{bmatrix}, \\
X_t &= \begin{bmatrix} g_t \\ q_t \\ v_t \\ p_t \\ \omega_t \end{bmatrix}.
\end{aligned}
$$

Given inflation dynamics in equations (13)-(15), the two period per period log inflation risk premium can then be computed as:

$$
\begin{aligned}
& r_{t,2}^{\$} - r_{t,2} - \frac{1}{2}[(1+\phi_{pp})p_t + \mu_p(1-\phi_{pp})] = \\
& -\frac{1}{4}\sigma_{\pi\pi}^2 + \\
& \frac{1}{2}\sigma_{pq}[\gamma\sigma_{qq}(\phi_{qq} + \frac{1}{2}\gamma\sigma_{qq}) - \frac{1}{2}\sigma_{pq}]q_t - \\
& \frac{1}{4}\{-2\sigma_{pc}\gamma[-\sigma_{gc} + \phi_{qq}\sigma_{qc} + \frac{1}{2}\gamma\sigma_{qq}^2\sigma_{qc} + \frac{1}{2}\gamma(\sigma_{cc} - \sigma_{qc})^2\sigma_{vc} - \sigma_{cc}] + \sigma_{pc}^2 + \\
& \frac{1}{2}\gamma^2(\sigma_{cc} - \sigma_{qc})^2\sigma_{\pi\pi}^2\sigma_{vv}\sigma_{\omega v} + \frac{1}{4}\sigma_{\pi\pi}^4\sigma_{\omega v}^2\}v_t - \\
& -\frac{1}{4}[\sigma_{\pi\pi}^2\phi_{\omega\omega} + (-\sigma_{p\pi} + \frac{1}{2}\sigma_{\pi\pi}^2\sigma_{\omega\pi} - \sigma_{\pi\pi})^2]\omega_t.
\end{aligned}
$$

Appendix VI: One Quarter Nominal Rate Regressions

Regressions of One Quarter Nominal Rate on Economic Factors. Data is quarterly. Regressions are OLS regressions including constants. The sample is 2004Q4-2016Q2. Standard errors in parentheses are Newey and West (1987) standard errors computed with 8 lags. *, **, and *** indicate the statistical significance at the 10%, 5%, and 1% significance level, respectively.

France						
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Expected consumption growth	1.64***					0.21
	(0.33)					(0.19)
Consumption growth variance		-2.35*				-0.62
		(1.40)				(0.54)
Discretionary monetary policy			1.00*			0.17
			(0.64)			(0.20)
Macroeconomic risk aversion				-1.41***		-1.28***
				(0.12)		(0.15)
Financial risk aversion					-102.50	-42.12
					(126.17)	(37.93)
Adjusted R^2	52.44%	5.02%	8.06%	88.77%	-0.76%	91.16%

UK						
	Spec 1	Spec 2	Spec 4	Spec 5	Spec 6	Spec 7
Expected consumption growth	0.25					-0.06
	(0.50)					(0.40)
Consumption growth variance		-2.68				0.35
		(1.84)				(1.11)
Discretionary monetary policy			1.00***			0.26
			(0.35)			(0.27)
Macroeconomic risk aversion				-1.92***		-1.80***
				(0.23)		(0.32)
Financial risk aversion					-205.27	-258.69**
					(149.32)	(126.05)
Adjusted R^2	-1.19%	2.88%	25.35%	80.65%	-0.10%	82.87%

US						
	Spec 1	Spec 2	Spec 4	Spec 5	Spec 6	Spec 7
Expected consumption growth	0.56					0.05
	(0.49)					(0.23)
Consumption growth variance		-3.16				3.23
		(6.81)				(2.63)
Discretionary monetary policy			1.00**			0.58***
			(0.40)			(0.11)
Macroeconomic risk aversion				-1.69***		-1.22
				(0.22)		(0.15)
Financial risk aversion					-340.04*	-355.35***
					(204.44)	(95.89)
Adjusted R^2	1.91%	-1.46%	39.74%	85.31%	7.46%	94.72%

Regressions of One Quarter Nominal Rate on Expected Inflation, Output Gap, and Macroeconomic Risk Aversion. Regressions are OLS regressions including constants. The sample is 2004Q4-2016Q2. Standard errors in parentheses are Newey and West (1987) standard errors computed with 8 lags. *, **, and *** indicate the statistical significance at the 10%, 5%, and 1% significance level, respectively.

	France	UK	US
Expected inflation	0.39	1.10***	1.00*
	(0.29)	(0.26)	(0.55)
Output gap	0.39***	0.50***	-0.02
	(0.12)	(0.16)	(0.11)
Macroeconomic risk aversion	-0.72***	-1.41***	-1.48***
	(0.17)	(0.26)	(0.22)
Adjusted R^2	93.00%	88.67%	87.05%

Appendix VII: Model Fit: Additional Moments and Specifications

VII.A: Additional Moments Fit

Model-implied 5 Year Real and Nominal Yield Levels. Data GMM standard errors computed using 12 Newey and West (1987) lags (months) are in parentheses. Subsample 1 is 2004Q4-2010Q2. Subsample 2 is 2010Q3-2016Q2. In Panel A, in Model 1, the only factor determining real yields is macroeconomic risk aversion, in Model 2, the only factor determining real yields is discretionary monetary policy shocks, and in Model 3, both macroeconomic risk aversion and monetary policy shocks are real yield determinants. In Panel B, the real yield model is a one-factor where the only factor is macroeconomic risk aversion, and the inflation risk premium model is a three-factor model, where the factors are macroeconomic risk aversion, financial risk aversion and discretionary monetary policy.

Panel A: Real Yields

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	-0.00%	0.85%	-0.85%	-0.81%	0.61%	-2.24%	-0.06%	0.79%	-0.91%
	(0.33%)	(0.27%)	(0.17%)	(0.51%)	(0.52%)	(0.14%)	(0.34%)	(0.33%)	(0.27%)
Model 1	-0.00%	0.88%	-0.88%	-0.81%	0.47%	-2.11%	-0.06%	0.66%	-0.76%
Model 2	-0.00%	0.10%	-0.09%	-0.81%	-0.09%	-1.57%	-0.06%	0.44%	-0.55%
Model 3	-0.00%	0.89%	-0.88%	-0.81%	0.60%	-2.23%	-0.06%	0.73%	-0.83%

Panel B: Nominal Yields

	France			UK			US		
	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2	Full sample	Subsample 1	Subsample 2
Data	2.14%	3.25%	1.02%	2.69%	3.99%	1.39%	2.39%	3.44%	1.34%
	(0.43%)	(0.32%)	(0.31%)	(0.46%)	(0.42%)	(0.15%)	(0.40%)	(0.47%)	(0.15%)
Model	2.14%	3.28%	1.01%	2.69%	3.77%	1.64%	2.39%	3.30%	1.49%

VII.B: World β Specification

Macroeconomic risk aversion in each country is assumed to be:

$\beta_{\text{country},0} + \beta_{\text{country},1} \cdot$ world macroeconomic risk aversion $+$ country-specific component.

World macroeconomic risk aversion is an average of macroeconomic risk aversions in France, UK, and the US. $\beta_{\text{country},0}$ and $\beta_{\text{country},1}$ are estimated separately for each country for the whole sample by regressing country-specific risk aversion on the world macroeconomic risk aversion. Country-specific components are residuals from these regressions.

Assuming that the real yield is a one-factor model of macroeconomic risk aversion (with the loading estimated over the whole sample for each country separately), the model-implied correlation between real yields in different countries is:

$$\frac{\beta_{\text{country 1},1}\beta_{\text{country 2},1}Var(\text{world macro ra})}{(\sqrt{\beta^2_{\text{country 1},1}Var(\text{world macro ra})+Var(\text{country-specific component}_1)})(\sqrt{\beta^2_{\text{country 2},1}Var(\text{world macro ra})+Var(\text{country-specific component}_2)})}.$$

We can compute model-implied full sample and subsample correlations by computing unconditional variances Var(world macro ra), Var(country-specific component$_1$),

and Var(country-specific component$_2$) in the full sample and subsamples.

Data and Model-implied Real Yield Correlations. The model is one-factor model where macroeconomic risk aversion is the only factor. GMM-based standard errors using 12 Newey and West (1987) lags are in parentheses.

Panel A: France-UK			
	Full sample	Subsample 1	Subsample 2
Data	0.86	0.68	0.37
	(0.12)	(0.16)	(0.23)
Model	0.93	0.85	0.36
Panel B: France-US			
	Full sample	Subsample 1	Subsample 2
Data	0.75	0.58	-0.08
	(0.10)	(0.20)	(0.26)
Model	0.93	0.86	0.35
Panel C: UK-US			
	Full sample	Subsample 1	Subsample 2
Data	0.90	0.78	0.61
	(0.06)	(0.18)	(0.16)
Model	0.96	0.91	0.52

Appendix VIII: Estimation of Consumption Growth-Expected Inflation Covariance

The estimation of the conditional consumption growth-expected inflation covariance consists of three steps. First, we extract the shocks to consumption growth and expected inflation. The consumption shock, ϵ_t^g, is the residual from regressing realized consumption growth on its two lagged values, and 1 and 5 year ahead survey expected consumption growth. The expected inflation shock, $\epsilon_t^{x^\pi}$, is the residual from regressing expected inflation on its lagged value. For the US we use 1 quarter expected inflation; for the UK and France, we assume that 1 quarter expected inflation is equal to 1 year ahead expected inflation (since 1 quarter ahead inflation surveys are not available for these countries).

Second, we construct conditional variances of both ϵ_t^g and $\epsilon_t^{x^\pi}$ independently from each other. We use GJR-GARCH model of Glosten, Jagannathan, and Runkle (1993). The model is as follows:

$$\epsilon_t \sim \mathcal{N}(0, \sigma_t^2),$$

$$\sigma_t^2 = \bar{\sigma}^2 + \rho(\sigma_{t-1}^2 - \bar{\sigma}^2) + \phi\epsilon_t^2 \mathbb{1}_{\epsilon_t \geq 0} + \phi_n \epsilon_t^2 \mathbb{1}_{\epsilon_t < 0},$$

where $\mathbb{1}$ is the indicator function.

Third, given the conditional variances we construct scaled shocks, u_t^g and $u_t^{x^\pi}$, by dividing ϵ_t^g and $\epsilon_t^{x^\pi}$ by their respective conditional standard deviations. Given the scaled shocks, we estimate the dynamic conditional correlation model of Engle (2002):

$$\begin{bmatrix} u_t^g \\ u_t^{x^\pi} \end{bmatrix} \sim \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, R_t \right),$$

$$R_t = diag\{Q_t\}^{-1} Q_t diag\{Q_t\}^{-1},$$

$$Q_t = S(1 - \alpha - \beta) + \alpha(u_{t-1}^g u_{t-1}^{x^\pi}) + \beta Q_{t-1},$$

where S is the unconditional variance-covariance matrix of u_{t-1}^g and $u_{t-1}^{x^\pi}$.

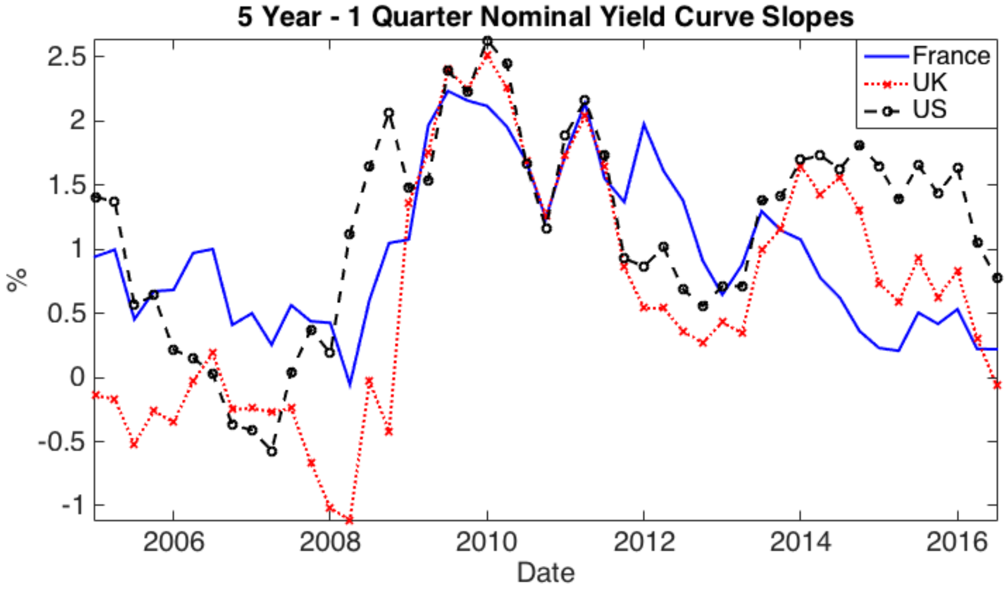
The conditional covariances can be now computed by multiplying the conditional standard deviations from the GJR-GARCH model by the conditional correlation from the dynamic conditional correlation model. All models are estimated separately for each country using quarterly data via the maximum likelihood. The parameter estimates are below.

GJR-GARCH and Dynamic Conditional Correlation Parameter Estimates. The sample is quarterly 2004Q4-2016Q2. Parameters are estimated via maximum likelihood. Standard errors in parentheses are computed as the square roots of the diagonal elements of the inverse information matrix.

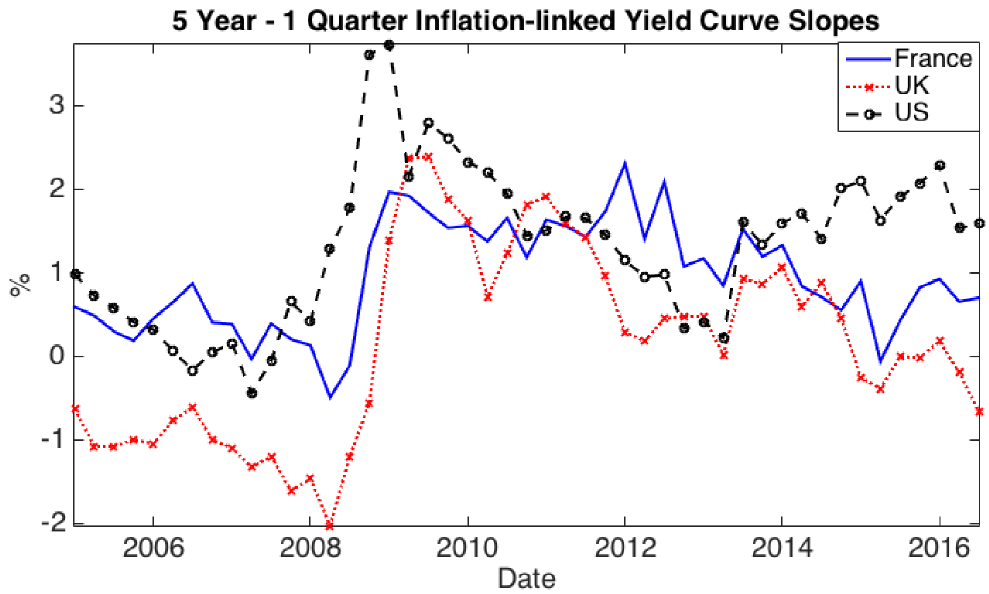
Panel A: Consumption growth shocks GJR-GARCH model estimates			
	France	UK	US
$\bar{\sigma}^2$	0.0898	0.2448	0.0621
	(0.0356)	(0.0992)	(0.0239)
ρ	0.5832	0.7412	0.5423
	(0.1671)	(0.0712)	(0.0648)
ϕ	0.0037	0.0151	0.0043
	(0.1898)	(0.2613)	(0.2353)
ϕ_n	0.5027	0.1693	0.3903
	(0.3877)	(0.1105)	(0.4074)
Panel B: Expected inflation shocks GJR-GARCH model estimates			
	France	UK	US
$\bar{\sigma}^2$	0.0242	0.0268	0.0087
	(0.0053)	(0.0049)	(0.0009)
ρ	0.3520	0.5819	0.7251
	(0.1603)	(0.1463)	(0.1795)
ϕ	0.0018	0.7813	0.7041
	(0.1850)	(0.4629)	(0.2989)
ϕ_n	0.0777	0.0159	0.0028
	(0.0304)	(0.1385)	(0.1574)
Panel C: Dynamic conditional correlation parameter estimates			
	France	UK	US
α	0.1103	0.0645	0.0818
	(0.0246)	(0.0153)	(0.0131)
β	0.8315	0.9331	0.9018
	(0.1117)	(0.1136)	(0.1834)

Appendix IX: Yield Curve Slopes

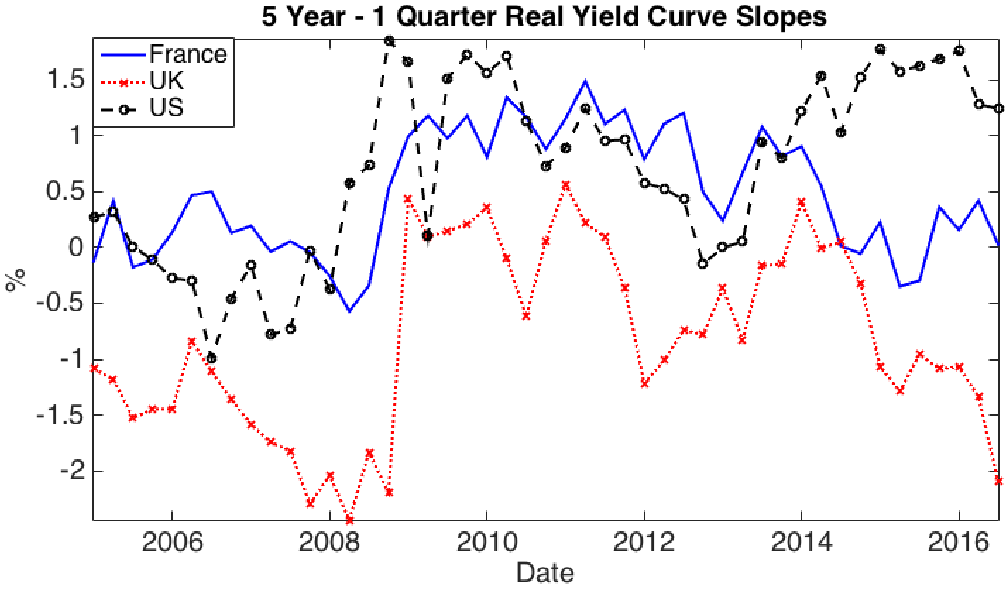
We use the same state variables as before, except that we replace expected 5 year consumption growth by its difference with the short term (one year) expected consumption growth series (see section 5.2). Because we investigate spreads, the expected coefficients are different. Recall that the term spread consists of the term premium plus an expectations hypothesis component minus the current short rate. If the short rate is a driftless random walk, the term spread entirely reflects premium behavior and should load on our risk variables. If the short rate mean reverts, level factors should enter with signs opposite to those observed for the levels of interest rates. The results are below. While many state variables are statistically significant in the univariate regressions, few are in the multivariate regressions. Macroeconomic risk aversion is now only statistically significant in the UK but does have a similar positive coefficient in the US. Recall that its effect on real interest rate levels was negative both for the short rate and the 5 year yield, the latter reflecting an expectations hypothesis level effect. A positive coefficient in the term spread regression suggests that the expectations hypothesis effect is not only canceled out but overturned by a positive term premium effect, at least in the UK. Financial risk aversion is strongly statistically significant for both the UK and the US with a positive sign, which almost surely reflects a term premium effect. Discretionary monetary policy has a statistically significant negative sign in France and the US, reflecting the imperfect passthrough of monetary policy effects on long rates. The expected consumption growth slope has a significant positive effect on the real slope, but only in France.



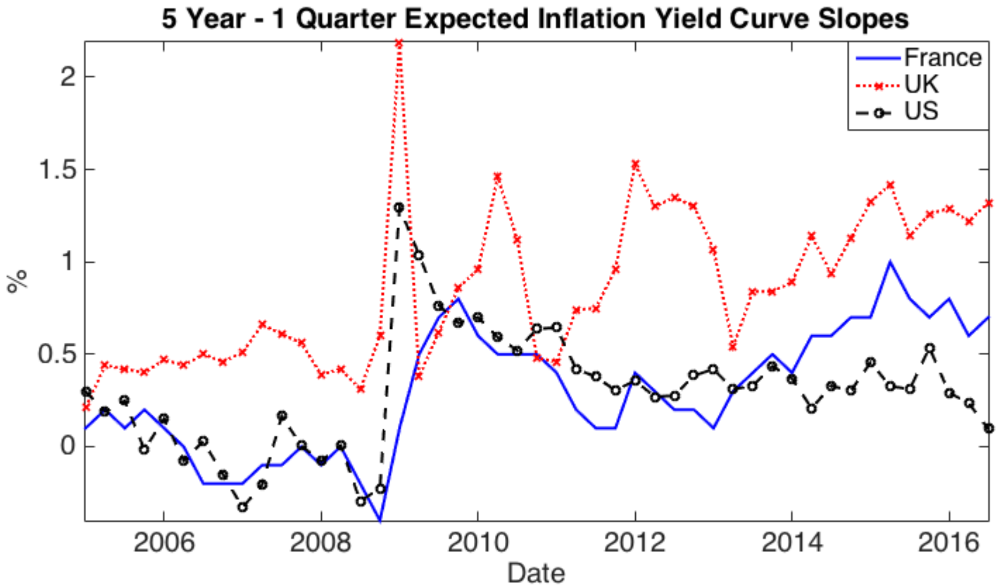
Nominal Zero-coupon Yield Curve Slopes.



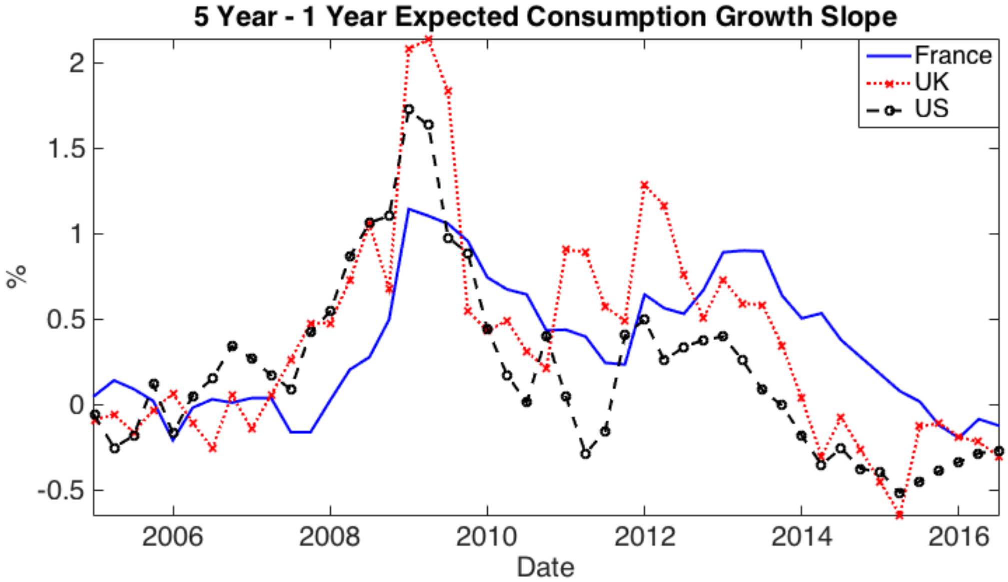
Inflation-linked Zero-coupon Yield Curve Slopes.



Real Zero-coupon Yield Curve Slopes.



Expected Inflation Yield Curve Slopes.



Expected Consumption Growth Slope. The slope is based on survey forecasts.

5 Year-1 Quarter Zero-Coupon Real Yield Curve Slope Regressions. Regressions are OLS regressions including constants. The sample is 2004Q4-2016Q2. Standard errors in parentheses are 8 quarters Newey and West (1987) standard errors.

			France			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Macroeconomic risk aversion	1.09					0.01
	(0.81)					(0.60)
Financial risk aversion		114.69***				-60.09
		(35.33)				(42.01)
Expected consumption growth slope			0.92***			0.92***
			(0.12)			(0.20)
Consumption growth volatility				1.44***		0.29
				(0.35)		(0.32)
Discretionary monetary policy					-0.51**	-0.51***
					(0.19)	(0.17)
Adjusted R^2	6.73%	11.38%	40.20%	17.94%	18.60%	53.64%
			UK			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Macroeconomic risk aversion	1.70***					2.03**
	(0.48)					(0.87)
Financial risk aversion		175.28***				193.68**
		(36.76)				(72.22)
Expected consumption growth slope			0.42**			-0.17
			(0.18)			(0.30)
Consumption growth volatility				1.52**		0.22
				(0.61)		(1.09)
Discretionary monetary policy					-0.04	0.16
					(0.18)	(0.19)
Adjusted R^2	27.48%	8.01%	7.89%	8.66%	-0.02%	34.89%
			US			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5	Spec 6
Macroeconomic risk aversion	3.82***					1.57
	(1.07)					(1.49)
Financial risk aversion		108.45				247.82*
		(78.63)				(138.97)
Expected consumption growth slope			-0.16			-0.34
			(0.37)			(0.41)
Consumption growth volatility				0.27		-0.91
				(3.51)		(2.86)
Discretionary monetary policy					-0.40***	-0.35***
					(0.15)	(0.12)
Adjusted R^2	39.90%	2.76%	-0.09%	0.17%	31.58%	53.73%

Appendix X: Additional International Evidence: Liquidity Premium Estimation

The liquidity premium is identified as in (3) except that the regression is run country-by-country, because a consistent set of liquidity proxies for all three countries is not available.

X.A: Liquidity Proxies

The liquidity proxies for Australia are the nominal off-the-run spread, the relative transaction volume of inflation-linked bonds, and the inflation swap spread. Annual bond transaction volumes were provided by Stephen Kirchner from Australian Financial Markets Association.

The liquidity proxies for Germany are the nominal off-the-run spread, the relative transaction volume of inflation-linked bonds, and the inflation swap spread. Semi-annual bond transaction volumes were provided by Christian Hirschfeld from Bundesrepublik Deutschland - Finanzagentur.

The liquidity proxies for Sweden are the nominal off-the-run spread, the relative transaction volume of inflation-linked bonds, and the 7 day STIBOR (Stockholm interbank Offered Rate) - Riksbank (Swedish Central Bank) repo rate spread. The monthly bond transaction volumes, STIBOR, and Riskbank repo rate are from Riskbank website.

X.B: Expected Inflation

For Australia, the available inflation expectations are 3 months ahead business inflation expectations, 1 and 2 year ahead union officials' inflation expectations, and 1 and 2 year ahead market economists' inflation expectations from Reserve Bank of Australia website. To extrapolate the inflation expectations, we use 1 and 2 year ahead market economists' inflation expectations. Using one and two year ahead union officials' inflation expectations doesn't affect the results. We estimate an AR(1) model of 1 year ahead inflation expectations. To compute inflation expectations for years 3-, we input the inflation expectations for the second year into the estimated AR(1) model and iterate forward.

German inflation expectations are Survey of Professional Forecasters mean estimates of 5 year ahead year on year percentage change of the Eurostat Harmonised Index of Consumer Prices from European Central Bank website. Swedish inflation expectations are All Interviewees' Median Expectations of 5 year inflation from TNS Sifo Prospera, an agency which conducts the inflation surveys for Riksbank, the Swedish Central Bank. Using mean instead of the median forecasts doesn't affect the results.